

**A Theoretical and Experimental Study
of Controllable Electricity Production
via Biogas Plants**

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A Theoretical and Experimental Study of the Controllable Electricity Production via Biogas Plants

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Abstract

With the expansion of renewable but fluctuating power generation from wind and solar energy, the demand placed on the security and reliability of supply is increasing. To ensure grid stability in the future, controllable power production via biogas plants has great technical and economic potential.

The main aim of this thesis is a new system design for controlled, demand oriented electricity production via biogas plants, based on system analyses and parameter studies. Derived aims are the analysis of new control strategies and required hardware modifications, e.g. storage capacities and CHP units.

Therefore the role of biogas in a future renewable based electricity system is discussed and different overall concepts for a controlled flexible electricity production via biogas are compared. Within a system analysis the current state of technology of biogas plant components, which are affected by a controllable electricity production is described. Building on this, technical requirements are characterised and technical recommendations are given. Since for the realisation of plant concepts for a controlled electricity production monetary incentive systems are needed. As a potential market the Day-Ahead Auction of the EPEX Spot Se were identified.

The concept development takes place via a parameter study, thereby various plant concepts are defined by varying the plant sizes, the additional electricity production capacities and the gas storage capacities. Before the actual economic analysis is carried out, different feasible control strategies and the associated earnings, based on different gas storage and electricity production capacities, are presented.

Within the economic analysis the necessary additional investment and operating costs for the controllable electricity are discussed and the costs are compared with possible higher revenues.

Based on the results of the concept development an existing biogas plant was modified in order to demonstrate the operation of the controllable electricity production via biogas plants. Within the monitoring, the ability of biogas plants to act as a controllable electricity producer were demonstrated. Also practical experiences with respect to the plant and component operation were made.

Acknowledgements

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Finally, I would like to thank my beloved partner Sandra, my parents Barbara and Walter, for their enduring support and their encouragement throughout the work.

I declare that the content of this submission is my own work. The contents of the work have not been submitted for any other academic or professional award. I acknowledge that this thesis is submitted according to the conditions laid down in the regulations. Furthermore, I declare that the work was carried out as part of the course for which I was registered. I draw attention to any relevant considerations of rights of third parties.

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Abbreviations

BG Zellerfeld	Biogas Plant Zellerfeld
CCGT	Combined Cycle Gas Turbine
cf.	compare (Latin: confer)
CH ₄	Methane
CHP	Combined Heat and Power Production
CO ₂	Carbon Dioxide
EEG	German Renewable Energies Act
EnWG	Energiewirtschaftsgesetz
EPDM	Ethylene Propylene Diene Monomer
EU 27	Member-States of the European Union since enlargement in 2007
GT	Gas Turbine
H ₂	Hydrogen
H ₂ O	Water
H ₂ S	Hydrogen Sulphide
HRT	Hydraulic Retention Time
MSW	Municipal Solid Waste
N ₂	Nitrogen
NH ₃	Ammonia
OTC	Over-The-Counter
O ₂	Oxygen

Ppm	Parts per Million
PSA	Pressure Swing Adsorption
PV	Photovoltaic
RES	Renewable Energy Sources
ROI	Return on Investment
€/kW _{rated} a	Euros per Year for each kW of Rated Power

Symbols and Subscripts

CC	Capacity Component	[€/kW]
$e_{EPEX,t}$	Electricity Price of EPEX Day-Ahead Auction at Time Step t	[€/kW _{el}]
f_{cor}	Correction Factor	
FP	Flexible Premium	[ct/kWh]
n	number of the CHP	
N	total number of the CHPs	
p_{abs}	Absolute Pressure	[bar]
p_G	Absolute Pressure of Dry Gas	[bar]
$P_{additional}$	Additional Installed Capacity	[kW]
$P_{CHP,el,n,t}^{gen}$	Electrical Power of CHP n at Time Step t	
P_{inst}	Installed Electrical Power	[kW]
P_{rated}	Rated Power	[kW]
p_s	Standard Pressure	[bar]
p_p	Partial Pressure of Water Vapour	[bar]
$r_{CHP,n,t}$	Revenue at Time Step t	[€]
t	Time Step	
T	Total Number of Time Steps	
T	Temperature	[K]
T_s	Standard Temperature	[K]

V	Volume	$[m^3]$
V_s	Standard Volume	$[Nm^3]$
φ	Relative Humidity	$[\%]$

1 Introduction and Background

1.1 Background

In 2010, 52 GW of a total of 135 GW installed electric power generation capacities in Germany were based on renewable energies. The major part of the renewable electricity production (wind-onshore, wind-offshore, photovoltaic (PV)), however, produces not on demand but fluctuating electricity. By 2020, the ratio will be inverted. At this point, the power generation capacity of renewable energies will be more than twice that of conventional power plants. This evolution will continue in the years ahead (Sachverständigenrat für Umweltfragen 2010) ([Figure 1.1](#)).

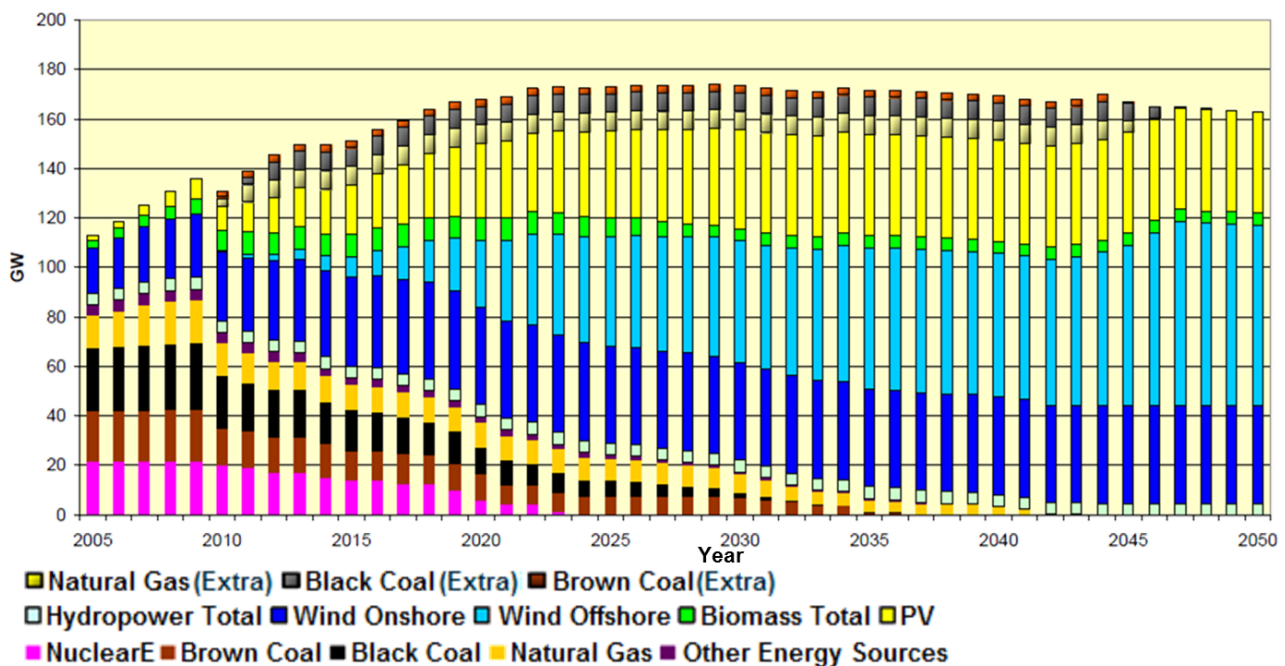


Figure 1.1: Scenario for the development of electricity generation capacity in Germany until 2050 (Sachverständigenrat für Umweltfragen 2010)

The trend towards renewable power generation leads to several challenges which have to be faced. In times when the conventional power plants dominate, the fluctuating electricity production from wind energy and photovoltaic can be compensated easily. In the future, the installed power generation capacities from renewable energies will exceed the ability of the conventional power plants to compensate the fluctuating electricity production. This will lead to a lack or a surplus of electricity in the grid.

Currently, the electricity production in Germany is only on demand. Due to a rising amount

of fluctuating renewable electricity producers, the electricity production will be carried out primarily on its availability in the future. This means, the production of electricity is not congruent with the demand and there are periods with a lack or with a surplus of electricity in the grid.

In times of underproduction, additional electricity capacities are needed; in periods of overproduction the surplus of electricity must be stored for periods of underproduction. To ensure grid stability in the future, improving load management and new storage technologies have to be developed.

Biogas has the ability to be stored and a higher efficiency can be achieved for the storage of energy in comparison to pumped-storage hydroelectricity, compressed-air energy storage or in the form of hydrogen. Therefore, the controllable power production from biogas has a high technical and economic potential.

1.2 Research Aim

Controllable electricity production via biogas plants depends on various factors. To achieve an economic optimum for corresponding concepts, suitable components, efficient control strategies and system configurations must be chosen.

The main aim of this thesis is a new system design for a controlled, demand oriented electricity production via biogas plants, based on system analyses and parameter studies. Derived aims are the analysis of new control strategies and required hardware modifications, e.g. storage capacities and CHP units.

The main research question that arises is:

How can concepts, suitable components, efficient control strategies and system configurations for a controlled demand oriented electricity production via biogas plants be designed to achieve an economic optimum and a reliable operation?

1.3 Research Objectives

1. To investigate the current state of affected components, the component requirements and incentives for controlled electricity production via biogas plants.
2. To develop plant concepts, that allows an economic and reliable operation.
3. To demonstrate the operation of a developed concept on a full-scale operational biogas plant.

1.4 Thesis Outline

The remainder of this thesis is structured as follows.

In chapter two, a comprehensive analysis of the current situation of the electricity production via biogas in Europe is described and the potential of a controlled electricity production via biogas plants in a future renewable based electricity production is examined.

Within chapter three a system analysis of the current state of technology of biogas plant components, which are affected by a controllable electricity production is described. Building on this, technical requirements are characterised and technical recommendations are given, which are entailed with the controllable electricity production. Monetary incentive systems for a controlled electricity production, potential markets and the current situation of the legal funding in Germany are also discussed within chapter three.

Chapter four presents the concept development. The approach within the parameter study is described, different control strategies are presented and an economic analysis of the developed concepts is carried out.

Chapter five presents the modification of an existing biogas plant in order to demonstrate the operation of the controllable electricity production. Also the results of the monitoring with respect to the plant and component operation are described.

The appendix includes the results of the parameter study and the galley proof of a peer-reviewed journal paper (Häring et al. 2017), which is based on this thesis, published in the journal Chemical Engineering and Technology.

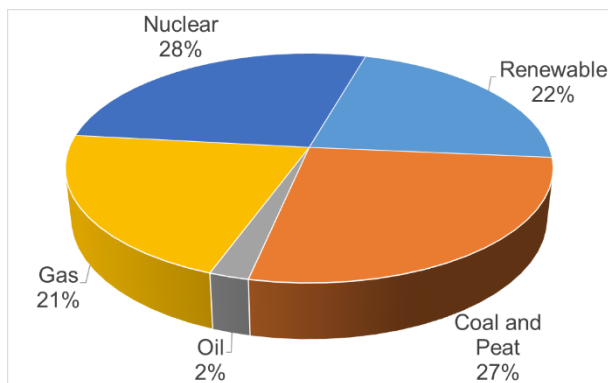
2 State-of-the-Art and Potential of the Controlled Electricity Production via Biogas Plants (Literature Review)

2.1 State-of-the-Art Electricity Production via Biogas Plants

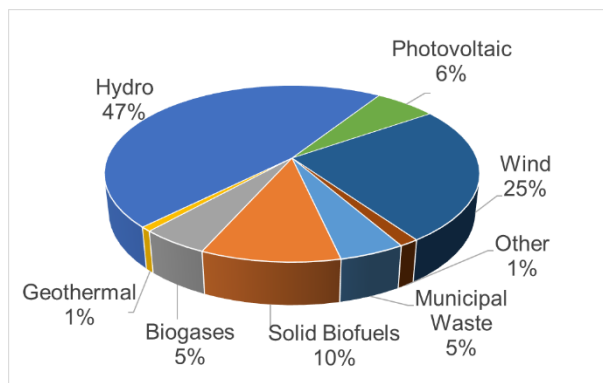
2.1.1 Biogas in Europe

Electricity production in Europe is based mainly on fossil energy sources. As [Figure 2.1](#) shows, in 2011 approx. 50 % of the electricity of the European Union member states (in total 3,279 TWh) were produced via fossil gas, coal and oil. 28 % of the electricity production was generated by nuclear power (iea 2014). The share of electricity produced via renewable energy sources (RES) was approximately 22 %.

The largest share of electricity production in the European Union among the RES have the energy sources water and wind ([Figure 2.1](#)). The share of biogases within the RES is approx. 5 % (iea 2014).



Electricity Production in General



Electricity Production from RES

Figure 2.1: Gross Electricity Production 2011 Regarding Energy Sources in the European Union (EU 27) (iea 2014)

Biogas can be distinguished according to its origin in agricultural, landfill, sewage and municipal solid waste (MSW) biogas.

[Table 2.1](#) shows the primary energy produced in 2011 differentiated according to the different biogases and the members of the European Union. Also the gross electricity and heat production via biogas in the countries of the European Union are shown.

The most utilisation of biogas takes place in Germany, the UK and Italy. Overall 31 % of the primary energy from biogas in the European Union comes from landfill gas, 12 % from sewage gas and 58 % from agricultural biogas. However, the used biogases in each country differ significantly. While in the United Kingdom, Italy and France mainly landfill gas is utilised, most of the energy in Germany, the Netherlands and Austria comes from agricultural biogas.

Table 2.1: Primary Energy, Gross Electricity and Gross Heat Production in the European Union in 2011 (euroobserver 2012)

Country	Primary Energy [TWh]			Total	Gross Electricity [TWh]	Gross Heat [TWh]
	Landfill Gas	Sewage Sludge Gas	Agricultural Biogas*		Total	Total
Germany	1.73	5.86	51.34	58.94	19.43	0.67
United Kingdom	17.24	3.28	0.00	20.52	5.74	
Italy	8.79	0.19	3.77	12.74	3.40	0.35
France	2.90	0.49	0.67	4.07	1.12	
Netherlands	0.37	0.60	2.42	3.39	1.03	0.07
Czech Republic	0.37	0.45	2.09	2.90	0.93	0.08
Spain	1.72	0.18	0.96	2.86	0.88	
Austria	0.05	0.19	1.61	1.85	0.63	0.12
Poland	0.55	0.79	0.23	1.57	0.43	0.17
Belgium	0.49	0.17	0.82	1.48	0.60	0.08
Sweden	0.14	0.80	0.44	1.39	0.33	0.17
Denmark	0.06	0.23	0.85	1.14	0.34	0.34
Greece	0.64	0.19	0.02	0.85	0.20	
Ireland	0.51	0.10	0.07	0.67	0.20	
Slovakia	0.03	0.16	0.34	0.53	0.11	0.04
Portugal	0.49	0.02	0.01	0.52	0.16	
Finland	0.28	0.16	0.06	0.49	0.09	0.10
Slovenia	0.08	0.03	0.30	0.42	0.13	0.06
Hungary	0.08	0.07	0.18	0.34	0.18	
Latvia	0.09	0.03	0.14	0.26	0.11	0.05
Luxembourg	0.00	0.02	0.13	0.15	0.06	0.01
Lithuania	0.07	0.04	0.02	0.13	0.04	0.01
Estonia	0.03	0.01	0.00	0.04	0.02	0.02
Romania	0.00	0.00	0.03	0.03	0.02	
Cyprus	0.00	0.00	0.01	0.01		
European Union	36.73	14.05	66.52	117.30	35.86	2.34
Share	31 %	12 %	58 %			

* Agricultural and Municipal Solid Waste

54 % of gross electricity and even 77 % of primary energy from biogases in the European Union are produced in Germany ([Table 2.1](#)). As shown in [Table 2.2](#), this is also reflected in the number of biogas plants in the different countries.

[Table 2.2](#): Numbers of Biogas Plants in Different European Countries (Green Gas Grids n.d.)

Country	Agricultural	Biowaste (incl. organic MSW)	Sewage Sludge Gas	Landfill Gas
Austria	300	55	134	14
France	40	98	60	71
Germany	7,400	100	1,007	
Hungary	36		14	
Italy	1,000	32	60	8
Netherlands	130			220
Poland	30	2	200	
Slovakia	34	4	10	9
UK	60		100	200
Sweden	26	26	135	55

In addition to Germany, there are four other countries in which the biogas sector currently shows a certain dynamic development: The United Kingdom, Italy, the Netherlands and France (Wellinger et al. 2013). These countries contribute 34.7 % of the amount of biogas of the European Union. However, 67.7 % of the biogas are derived from landfill or sewage plants. In these countries the feed-in tariffs are reasonably funded, so further development is possible (Weilinger et al. 2013).

The relatively high share of agricultural biogas plants in Germany is attributed to the German Renewable Energies Act (EEG). The EEG was introduced in 2000. Since the first revision of the act in 2004, the use of energy crops has been funded. This leads to the high amount of agricultural biogas plants. [Figure 2.2](#) shows the development of the number of agricultural biogas plants and the overall installed electric capacity in Germany between 2000 and 2012. From 2009 on the category for the installed electrical capacities between 70-500 kW_{el} was split in 70-150 kW_{el} and 151-500 kW_{el}. In Germany about 7,400 biogas plants with a total installed electric capacity of approximately 3,300 GW_{el} were in operation in 2012. Most of the biogas plants have an installed electric capacity between 150 and 500 kW_{el}.

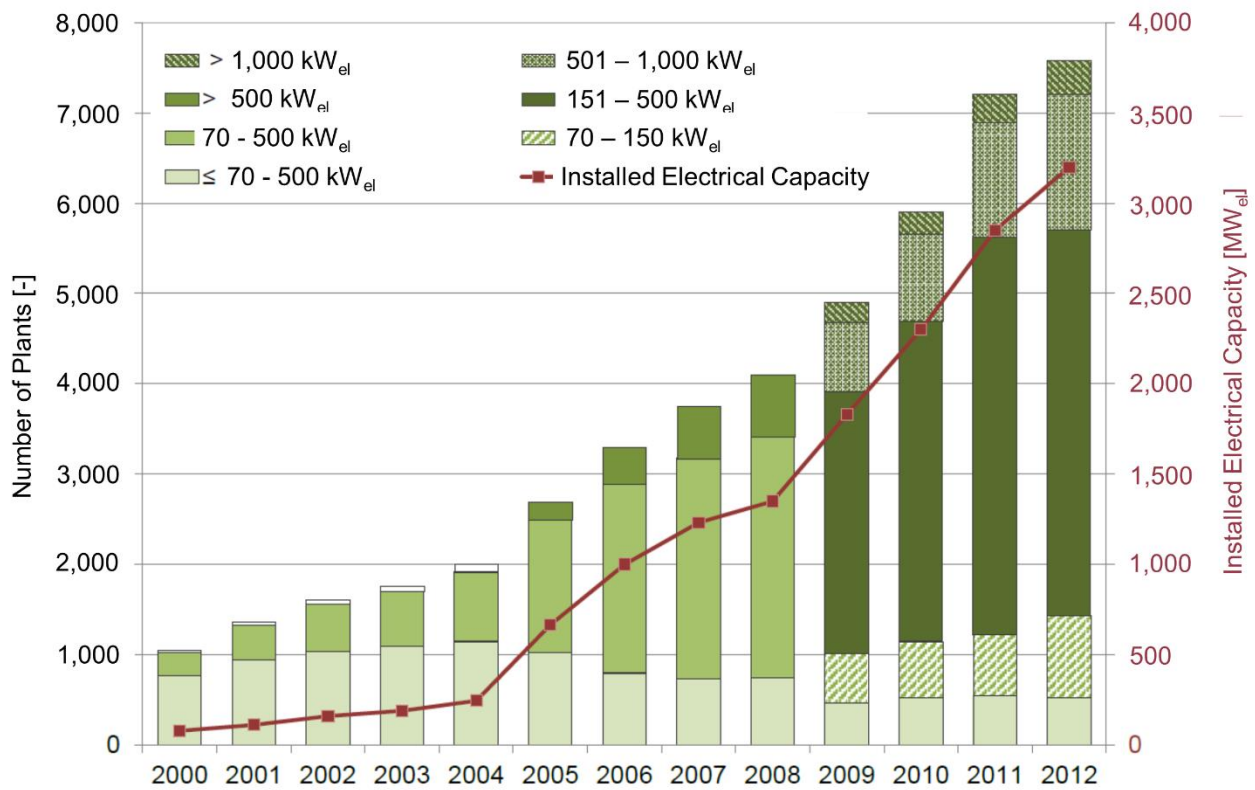
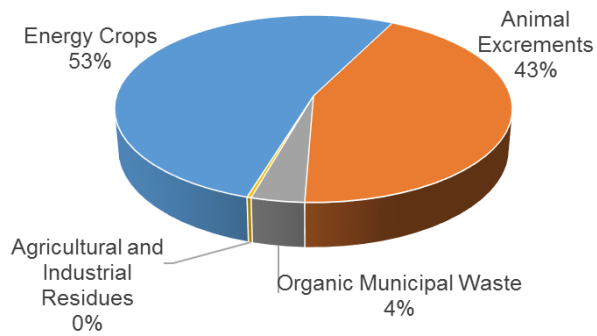
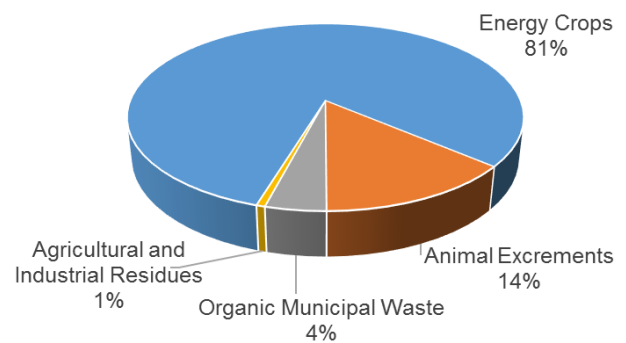


Figure 2.2: Development of Biogas plants in Germany
(Deutsches Biomasse Forschungszentrum 2013)

As shown in [Figure 2.3](#), in Germany 53 % of the substrate mass in biogas plants is energy crops and 43 % animal excrements (Deutsches Biomasse Forschungszentrum 2013). However, the biggest amount of energy produced originates from energy crops ([Figure 2.3](#)). Only about 14 % of the energy supply is due to the use of animal excrements. As [Figure 2.4](#) illustrates the most commonly used energy crop is maize.



Mass-Related Substrate Use



Energy-Related Substrate Use

Figure 2.3: Mass- and Energy-Based Shares of the Substrate Types in Germany
(Deutsches Biomasse Forschungszentrum 2013)

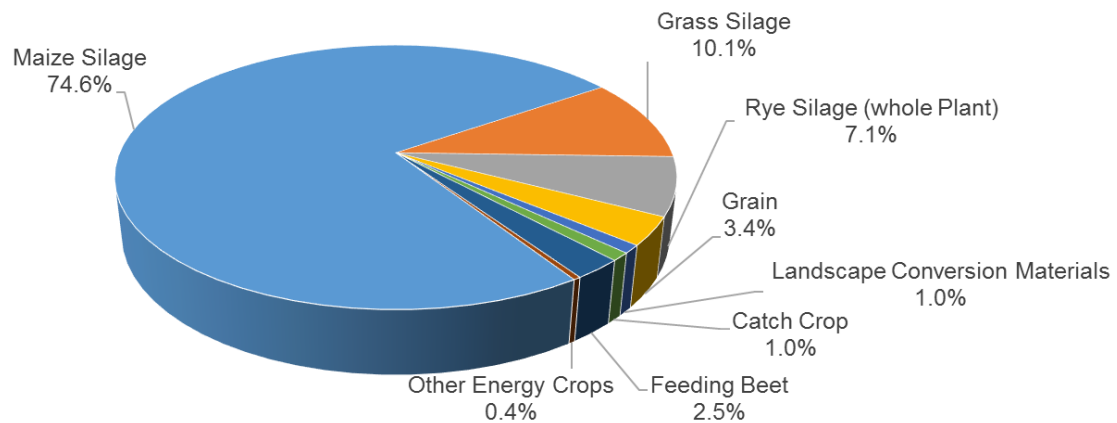


Figure 2.4: Shares of the used Energy Crops in Germany
(Deutsches Biomasse Forschungszentrum 2013)

2.1.2 Formation of Biogas

The anaerobic formation of biogas takes place in four separate phases ([Figure 2.5](#)) and involves a complex interaction of various microorganisms.

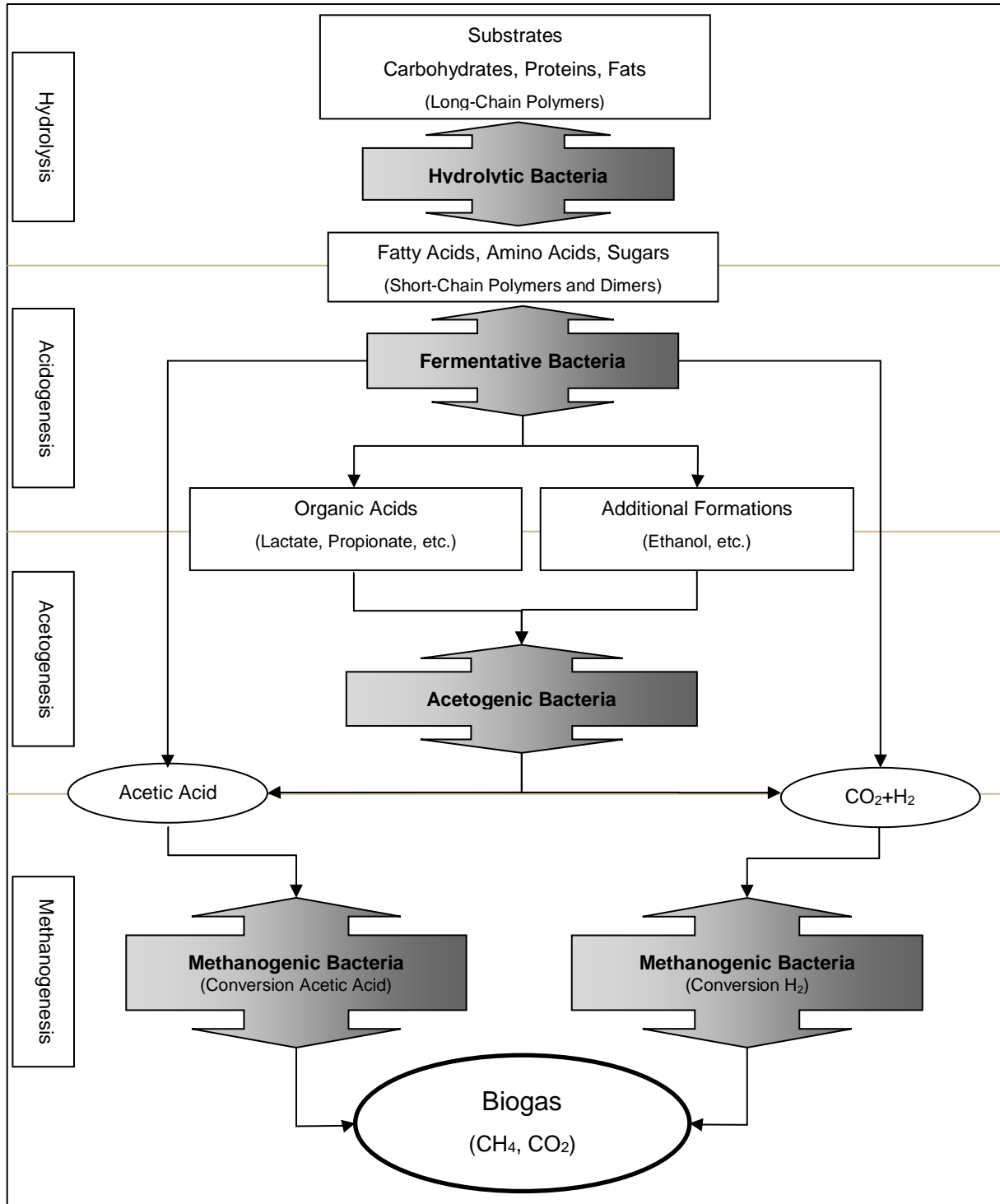


Figure 2.5: Anaerobic Degradation of Organic Material into Biogas (Kaltschmitt et al. 2009)

The first phase of the biogas formation is the hydrolysis phase. Via bacterial action long-chain organic compounds (e.g. carbohydrates, fats) are split into more simple organic compounds (e.g. fatty acids, amino acids, sugars).

Within the second phase, the acidification phase, the products of the first phase are formed into short-chain fatty acids (e.g. acetic, propionic and butyric acid) through acidogenic bacteria. Also acetic acid, hydrogen and carbon dioxide are produced.

In the third phase, the acetic acid formation, the organic acids and alcohols are split into acetic acid, hydrogen and carbon dioxide.

Within the methane formation, the former products, acetic acid, hydrogen and carbon dioxide form the basis for the methanogenic microorganisms, which form the biogas. The composition of the final biogas is shown in [Table 2.3](#).

Table 2.3: Composition of Biogas (Fachagentur für nachwachsende Rohstoffe 2013)

Component	Content [%]
Methane (CH₄)	50-75
Carbon Dioxide (CO₂)	25-45
Water (H₂O)	2-7
Oxygen (O₂)	< 2
Nitrogen (N₂)	< 2
Ammonia (NH₃)	< 1
Hydrogen Sulphide (H₂S)	< 1

The composition of the biogas as well as the biogas yield depend on the used substrates ([Figure 2.6](#)).

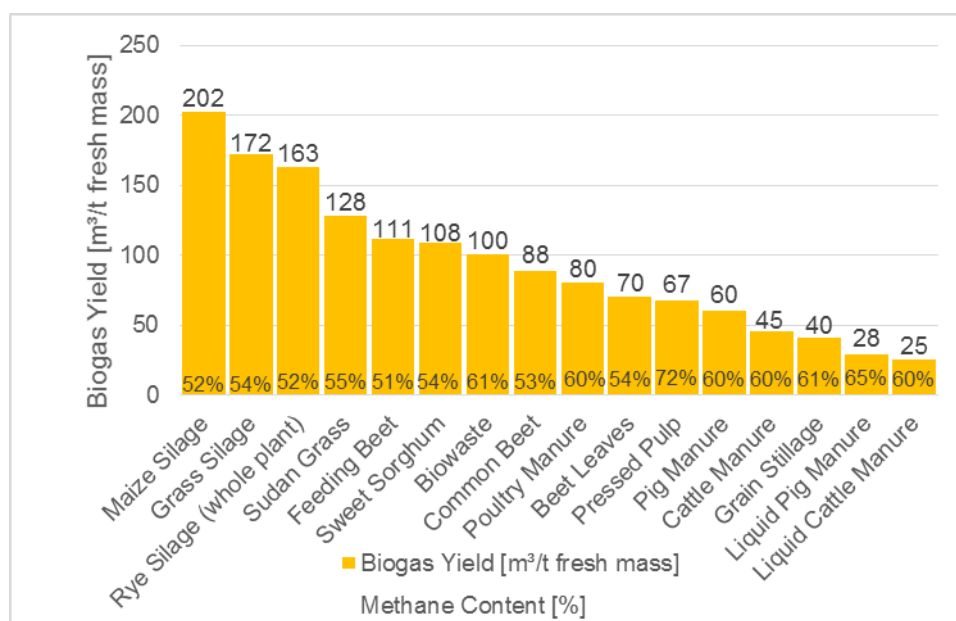


Figure 2.6: Methane Content and Biogas Yield of Various Substrates
(Fachagentur für nachwachsende Rohstoffe 2013)

Agricultural biogas plants usually consist of a liquid manure store, a feed-in unit for solid substrates, digesters, digestate storage tanks, gas storages and biogas utilisation units ([Figure 2.7](#)).

The common way of biogas production of agricultural biogas plants is a continuous process, characterised by a regular feeding of the digester. The substrate feed-in of the liquid manure and the solid substrates in the digester takes place several times a day. This results in stable process conditions and in a homogenous gas production. After the substrate is digested it is pumped into the digestate storage tank.

The hydraulic retention time (HRT) indicates the mean digestion time of the added feedstock into the digesters. The longer the feedstock remains in the digesters, the higher the gas yield. Common values of the HRT vary between 25 and 150 days (Fachagentur für nachwachsende Rohstoffe 2013).

Another important parameter for the digester is the volume load which indicates the amount of organic dry matter added to the digester per m³ of active digester and per time. It is a figure for the load of the biochemical process inside the digester. The hydraulic retention time and the volume load are inversely proportional. A high volume load means a high amount of added substrate, hence, a low hydraulic retention time.

Since the fermentation temperature is an important process factor, which influences the speed and the stability of the anaerobic digestion, it is necessary to insulate and heat the digesters in order to ensure the optimum temperature conditions. At biogas plants mesophilic conditions (between 35 and 42 °C) and thermophilic conditions (between 50 and 57 °C) are common. Approximately 85 % of the biogas plants in Germany are operated in mesophilic temperature ranges (Deutsches Biomasse Forschungszentrum 2013).

In the digesters, agitators ensure a homogenous distribution of the substrate and enable the escape of the gas from the substrate.

The produced biogas is temporarily stored in gasholders before it is utilised.

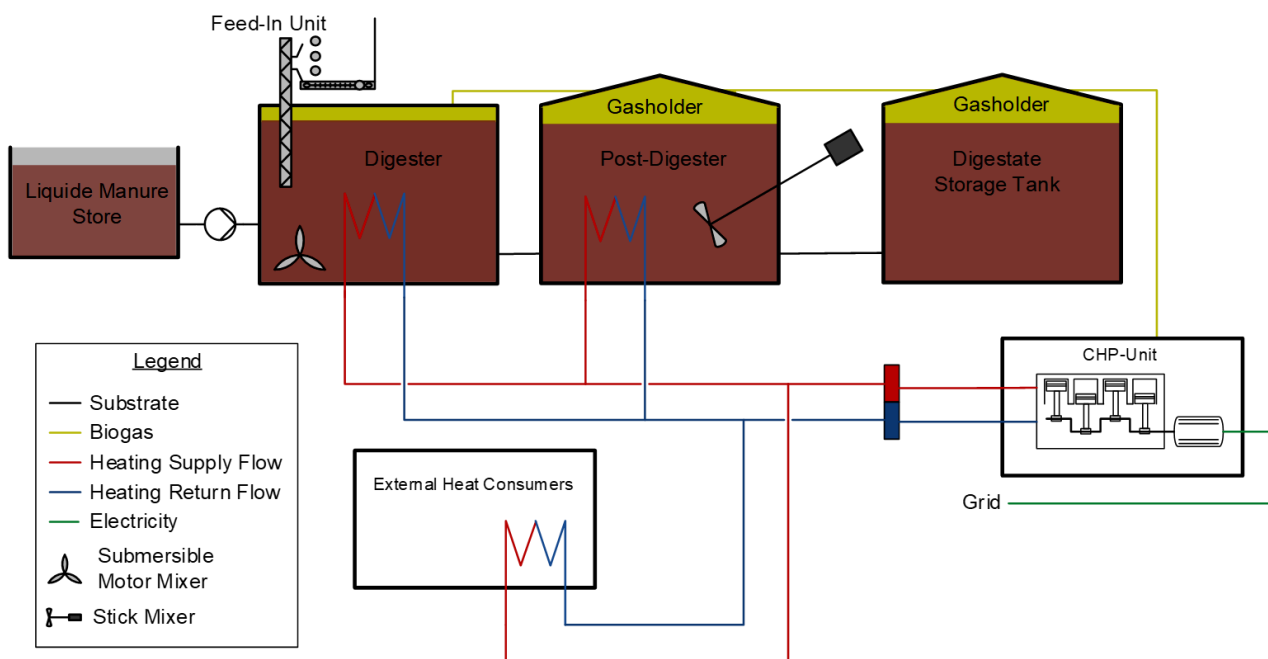


Figure 2.7: Scheme of an Agricultural Biogas plant

2.1.3 Utilisation of Biogas

Biogas is mainly used to produce electricity in combined heat and power production (CHP). In the past years, alternative biogas utilisation options have become increasingly relevant and are implemented in addition to the on-site conversion of biogas. The role of micro gas networks for a decentralized conversion of biogas as well as the upgrading of biogas to biomethane with subsequent gas injection into the natural gas grid have increasingly been applied. The possible utilisation paths are shown in Figure 2.8.

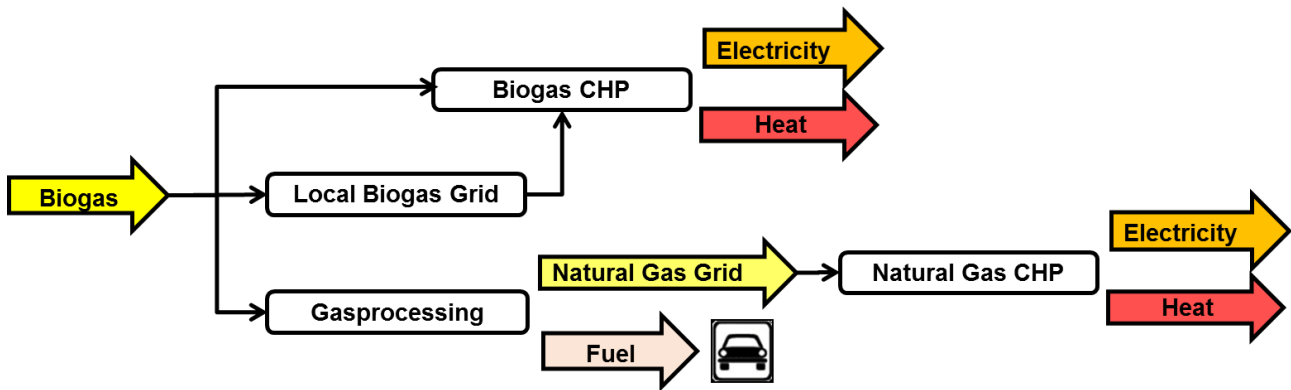


Figure 2.8: Utilisation Paths for Biogas

Biogas CHP

The biogas utilisation is usually done as a combined production of electricity and heat in CHP units. Adapted spark-ignited and ignition oil engines are common.

In practice, both types of engines are used in different performance classes. While spark-ignited engines are used in medium and higher power ranges ($> 250 \text{ kW}_{\text{el}}$), ignition oil engines are mainly used in small and medium power ranges up to $340 \text{ kW}_{\text{el}}$ (Deutsches Biomasse Forschungszentrum 2012). In Germany, spark-ignited engines are mainly used (75 % of the biogas plants). Only in 25 % of the plants ignition oil engines are used for the conversion of biogas (Deutsches Biomasse Forschungszentrum 2012).

Plant concepts in which the biogas is transported to the place of demand, are gaining more and more importance. In addition to the biogas upgrading, especially micro gas grids and the utilisation in satellite CHP units play a decisive role. The CHP is spatially separated from the biogas production and connected via a micro gas grid. In this way, the heat resulting in the CHP unit can be produced at the location of the heat consumer. So the heat utilisation can be improved. At about 21 % of the biogas plants in Germany micro gas grids are used (Deutsches Biomasse Forschungszentrum 2012).

Biogas Upgrading

The upgrading of biogas to 'biomethane' and the injection into the natural gas grid enables the usage of the existing and well developed public natural gas infrastructure. Thus, additional heat sources can be exploited and large gas storages, which are integrated in the natural gas grid, can be used for long term storage of biogas.

In July 2012, 137 plants in Europe with an overall feed-in capacity of about 70,000 Nm³_{Biomethane}/h were injecting biomethane into the public natural gas grids (biogaspartner n.d. a).

For the feed-in of the biomethane the raw biogas has to be upgraded to the required quality and caloric value of the corresponding natural gas grid.

The main upgrading steps are the desulphurisation, the removal of water, the separation of CO₂ and the adaption of the caloric values. The most important and most elaborate step is the separation of CO₂. The most common used methods for CO₂ separation in Europe are chemical scrubbing, pressure swing adsorption (PSA) and pressure water wash (biogaspartner n.d. a).

The biogas processing is associated with a high energetic effort for the CO₂ separation and the compression to the pressure level of the gas grid. The plants for CO₂ removal, adaption of the caloric values and compression require high investments. Thus, due to economies of scale mainly large biomethane plants with capacities above 250 Nm³_{Biomethane}/h are realised (biogaspartner n.d. b).

2.2 Controllable Electricity production via Biogas

2.2.1 Biogas in a Future Electricity System

With the energy concept of the German Federal Government in September 2010 (Federal Ministry for Economic Affairs and Energy 2010) and the act package in summer 2011 a long-term political timetable for climate protection and conversion of the energy supply in Germany was created. Therefore, the emissions of greenhouse gases in Germany in 2050 are to be reduced by 80 % up to 95 % in comparison to the year 1990.

To achieve this target, the minimum targets of the share of electricity production by renewable energies, listed in Table 2.4, were prescribed within the Renewable Energies Act 2012 (Federal Ministry of Justice 2012).

Table 2.4: Minimum Targets for the Share of Electricity produced by Renewable Energies (Federal Ministry of Justice 2012)

Year	Target
2020	35 %
2030	50 %
2040	65 %
2050	80 %

The energy concept of the German Federal Government is based on the Leitstudie 2011 (Nitsch et al. 2012). This study illustrates how this considerable challenge of the transformation of the energy system can be solved. Similar studies with congruent results were carried out by Barzantny et al. (2009), Sachverständigenrat für Umweltfragen (2010) and World Wild Fund of Nature (2009).

Within Nitsch et al. (2012), self-consistent energy scenarios for a long-term renewable energy expansion, considering the remaining energy supply and the resulting structural and economic effects, were developed. For this purpose, dynamic simulations of the future power supply were carried out. On the one hand, the scenarios of the electricity production were validated regarding the load coverage, on the other hand, the role of load balancing options, such as flexibility of power plants, electricity grid development, load management and the use of electricity storages were investigated.

Within the central scenario of this study, Scenario 2011 A, the contribution of renewable energies to the domestic electricity production rises from 103.5 TWh_{el}/a in 2010 to 427.4 TWh_{el}/a in 2050. The major part of the renewable energy electricity production is realised by wind energy and solar radiation as [Figure 2.9](#) illustrates. The production of electricity from biomass will be limited at about 60 TWh_{el}/a.

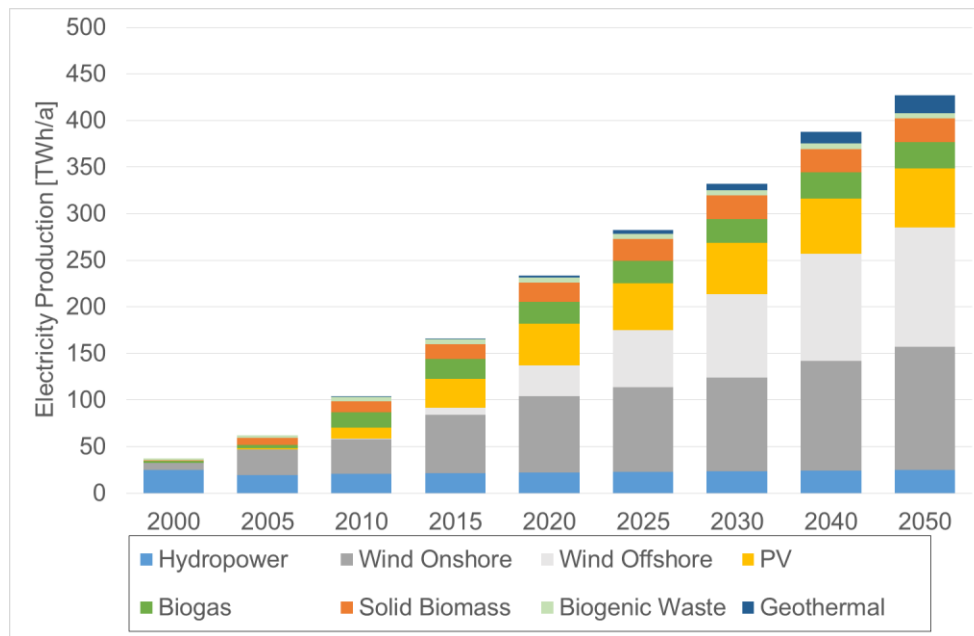


Figure 2.9: Electricity Production via Renewable Energies by type of Energy (Nitsch et al. 2012)

The electricity supply by renewable sources is, therefore, increasingly characterised by fluctuating sources. According to Nitsch et al. (2012) the fluctuating part of the electricity supply will raise from 8 % in 2011 to 28 % in 2020 and 55 % in 2050, based on the gross electricity consumption. This shows how fast the power plants and grids have to be adapted to the properties of renewable energies.

Since the runtime of the fluctuating energy sources sun (850 to 950 h/a) and wind (onshore 1,800 to 2,700 h/a; offshore 3,300 to 4,000 h/a) is low (Nitsch et al. 2012), a high installed power of these sources is necessary (Figure 2.10).

Already in 2020 RES will exceed the expected grid peak load of 80 GW_{el} with an installed power capacity of 117 GW_{el} (Nitsch et al 2012), and the proportion of the fluctuating electricity producers will significantly be predominant. This shows that at the latest from 2020 there is a large need for balance and storage options for RES-electricity.

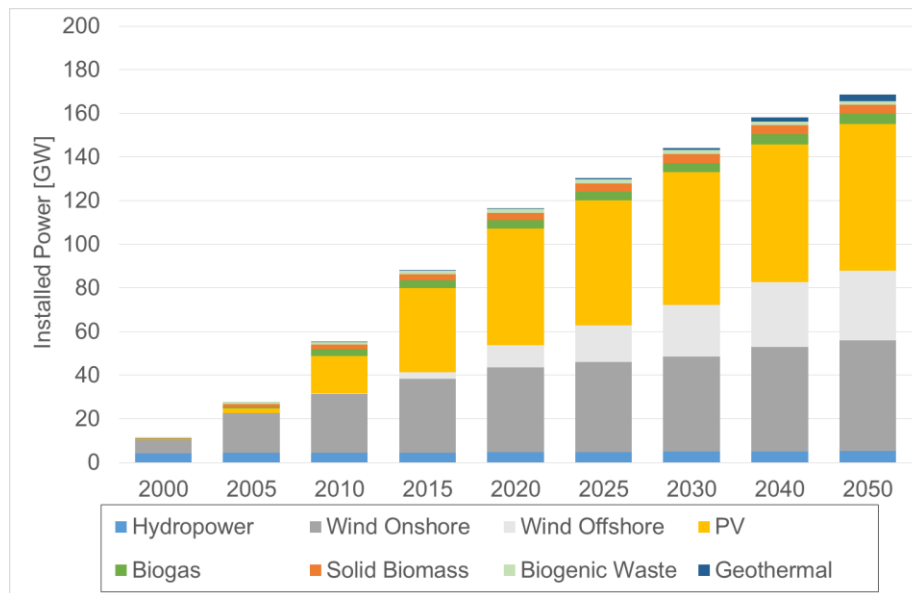


Figure 2.10: Installed Power of Renewable Energies by type of Energy (Nitsch et al.2012)

According to Nitsch et al. (2012), already 2020 an hourly full supply of electricity from RES can be expected. As Figure 2.11 illustrates, the fluctuations in the electricity system, which are created by the volatile supply from wind and PV, cause an effect on the residual load. The peak load demand rises and the base load gradually regresses to zero. In order to cover the highly volatile residual load and not to block the feed-in of RES, must-run units have to be reduced and the entire power plant stock has to be run flexibly. This flexibility is also necessary for biomass plants.

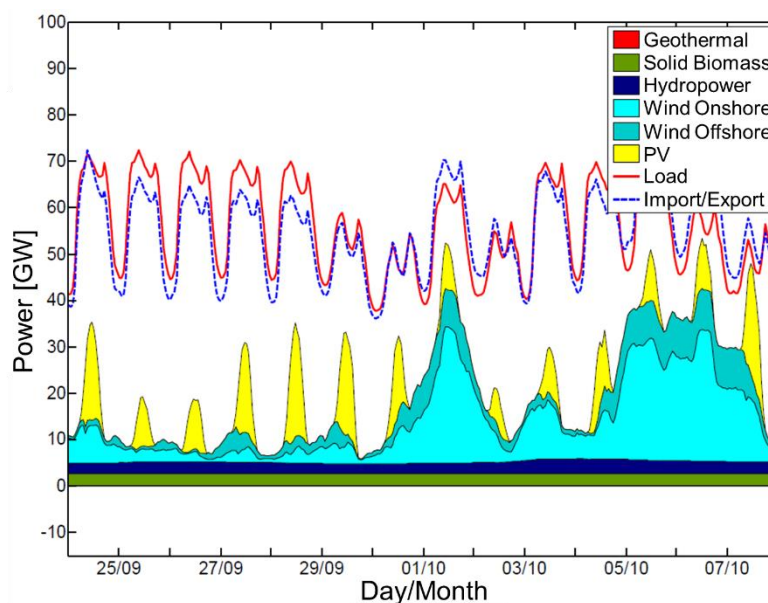


Figure 2.11: Supply-Dependent Feed-in, Electricity Demand and Electricity Import/ Export, Exemplary Course over two Weeks, without Biogas (Nitsch et al. 2012)

Figure 2.12 shows how this adaption to the changed residual load affects the utilisation of potentially controllable electricity producers. The utilisation of fossil fuelled condensing power plants in 2020 decreases significantly as compared to today, as well as the utilisation of the cogeneration between 2020 and 2050 (Nitsch et al. 2012). In 2050 biogas plants must be used flexibly with approx. 4,000 full load hours per year instead of the current base load feed-in.

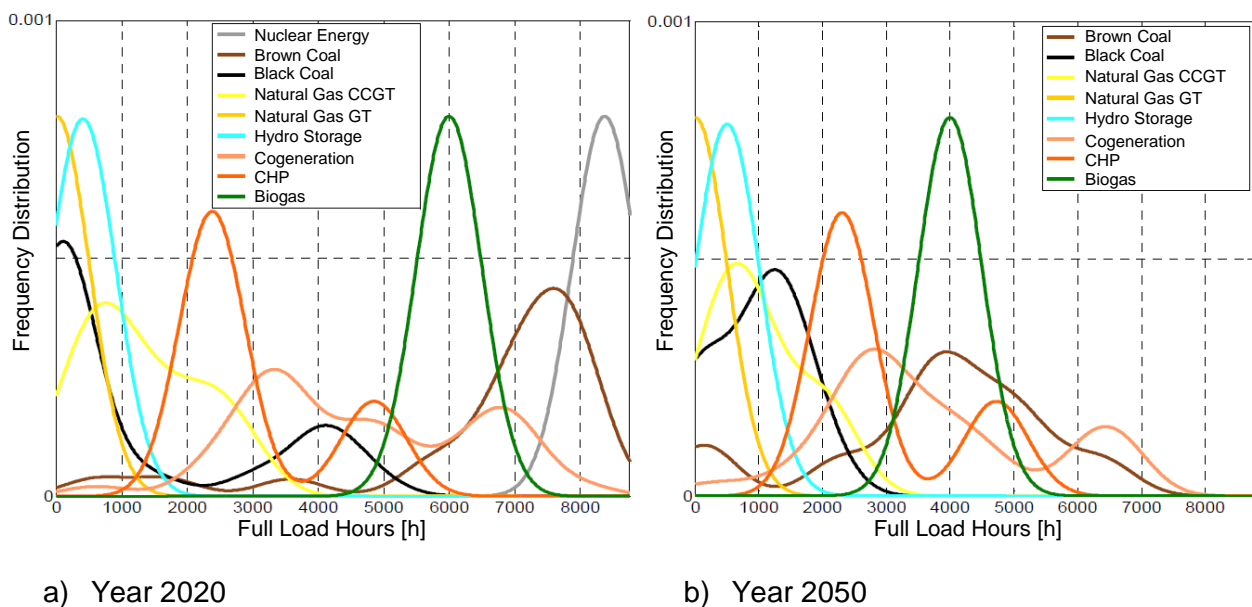


Figure 2.12: Utilisation of Hydro-Thermic Power Plants in 2020 and 2050 (Nitsch et al. 2012)

To meet these requirements for biogas in an electricity system characterised by fluctuating renewable electricity producers, further investigations regarding the explicit role of biogas and its impact on the system are necessary.

Furthermore for the large-scale integration of renewable energies, CHPs can significantly contribute to grid stabilization (Lund et al. 2012).

Hartmann et al. (2010) investigated the avoided specific electricity production costs by conventional electricity producers in order to determine the monetary value of electricity produced by biogas plants in the year 2020. Based on Nitsch et al. (2009) the load which has to be covered by conventional power plants in 2020 was calculated regarding the different flexibilities for the electricity produced by biogas as illustrated in Table 2.5.

Aim in this analysis was to cover fluctuations through sun and wind as well as peak loads with electricity produced with biogas. Therefore, the use of biogas was planned iteratively over a time period of 24 h using a simplex optimisation algorithm through a load-dependent

price function. Within this study the entire biogas power was aggregated. Individual biogas plants, or different plant concepts were not considered in these simulations.

The simulation regarding the covering of the remaining residual load with conventional power plants was carried out by a merit-order-list based plant scheduling model. As a result, the scenario for the maximum flexibility of biogas plants with no limitations leads to avoided electricity production costs of about 30 % (see [Table 2.5](#)). However, due to the necessary high production capacities, a scenario with no limitations is not practicable for the mainly used In-situ electricity production.

Table 2.5: Load Coverage by Biogas in the Scenarios of Hartmann et al. (2010)

Scenario	Power factor	Installed Power [GW]	Full Load Hours [h/a]	Storage Capacity (h Nominal Power)	Avoided Electricity Production Costs Compared to A
A Base Load	1	1.76	8.000	-	-
B Low Flexibility	1.5	2.64	5.333	8	6 %
C Middle Flexibility	2	3.53	4.000	12	10 %
D High Flexibility	4	7.05	2.000	18	25 %
E No Limitations	24	42.3	333	23	30 %

Holzhammer et al. (2013a) examined the CO₂ emissions in 2030 depending on different flexibilities for the production of electricity from biogas. For this purpose he evaluated the residual load which has to be covered by conventional power plants analogous to Hartmann et al. (2010). Holzhammer varied the time period for the provision of biogas between day, week and year. As a result, the flexibilisation of the electricity production from biogas leads to a reduction of CO₂ emissions by 2 % to 8 %. The reduction is mainly influenced by the flexibility of the electricity production (full load hours and supply during day or year) as well as by the electricity generation potential of biogas (min: 30.5 TWh_{el}, max. 52 TWh_{el}).

2.2.2 Concepts for a Controlled Electricity Production by Biogas Plants

Two basic concepts for a controllable flexible electricity production by biogas are available (Gerhardt 2009, Szarka et al. 2013). The gas can be produced on demand or can be stored

until it is utilised. In order to produce the same amount of electricity in shorter times, all concepts for a controlled electricity production require additional units for the conversion of biogas to electricity.

For the storage of biogas the following options are possible:

- In-situ storage – The biogas is stored in spatial proximity to the gas production and combustion.
- Upgrading of the produced biogas to bio-methane – Utilisation of the natural gas grid as a gas storage for a decoupled electricity production of bio-methane.

In the field of a flexible gas production there are the following approaches (Gerhardt 2009):

- Feeding management – Decreased or increased feed-in of easily or not-easily degradable substrates.
- Disintegration – Increasing the biodegradability of the substrate by mechanical, chemical or thermal treatment.
- Fixed-bed digesters – Fixation of methane-producing microorganisms on a fixed-bed.

Storage of Biogas

Storing biogas temporarily allows a continuous production of biogas. Different load profiles can be compensated by appropriately sized gasholders.

Hartmann et al. (2010) describes the potential of existing biogas plants to produce controllable electricity. The authors assume, based on own experience and on the in Fachagentur Nachwachsende Rohstoffe e.V. (2009) described average electrical usage rate of the CHP units of about 85 %, that the CHP units of the existing plants in Germany are mostly oversized. Considering the limited average gas storage capacity of 6 h, the power generation can be switched over a period of 15 h using a range of 80...120 % of the electric capacity.

Previous scientific work regarding the cost of the controllable electricity production by biogas plants is described in Schmid et al. (2009), Hartman et al. (2010), Rohrig et al. (2011) and Keymer (2013). There, the additional investments for components such as CHP units, gas-holder and heat storages are determined on the basis of literature values.

The overall system 'biogas plant as controllable energy producer', however, has not yet been designed on the basis of engineering methods.

Basis for the design of concepts for a controllable and flexible electricity production by biogas is the question which residual electricity demand fluctuations are intended to be compensated. The design of such biogas plants depends on the period for which the electricity demand should be covered and with which flexibility (annual full load hours of the individual biogas plant) this should be achieved.

The residual load to be covered depends on fluctuations in a daily, weekly and annual temporal course. These are a result of fluctuations through the electricity produced from RES as well as fluctuations in the load (electricity demand) (see [Table 2.6](#)).

Table 2.6: Residual Load Variations due to Different Influencing Factors (Holzhammer et al. 2013b)

Cause Variable	Day	Week	Season / Year
RES Production	PV, Depending on Solar Radiation	No Specific Dependence	Dependence on Weather (Especially Wind, also PV – Less Solar Radiation in Winter)
Load (Electricity Demand)	Various Demands During the Day	Less Electricity Demand on Weekends and Holidays	Dependence of the Demand on Weather Conditions

Holzhammer et al. (2013b) investigates the theoretically required gas storage capacity for these different temporal courses and different flexibilities for the electricity system in 2030 according to Nitsch et al. (2012) (see chapter 2.2.1).

The basis for Holzhammer's analysis was a standard biogas plant of 500 kW_{el} at 8,000 full load hours per year. This corresponds to an average power of 457 kW_{el} and an annual electricity production of 4,000 MWh_{el}. [Table 2.7](#) presents the investigated flexibilities and associated installed electrical capacities for the considered standard biogas plant.

Table 2.7: Electrical Capacities for each Flexibility (Holzhammer et al. 2013b)

Full Load Hours per Year [h/a]	8,000	5,500	4,000	2,500	1,500
Installed Electrical Capacity [kW]	500	727	1,000	1,600	2,667

If these capacities are used during the highest residual loads in the respective temporal course, the biogas storage capacities as shown in [Figure 2.13](#) are necessary. The increase of the periods of time for demand consideration lead to a strong increase of the necessary gas storage capacity. During the day at 1,500 full load hours per year, the required gas storage volume is 3,500 Nm³, during the week at about 25,000 Nm³ and during the year at approximately 235,000 Nm³. The influence of the full load hours on the required gas storage decreases with increasing periods for the demand consideration (Holzhammer et al. 2013b).

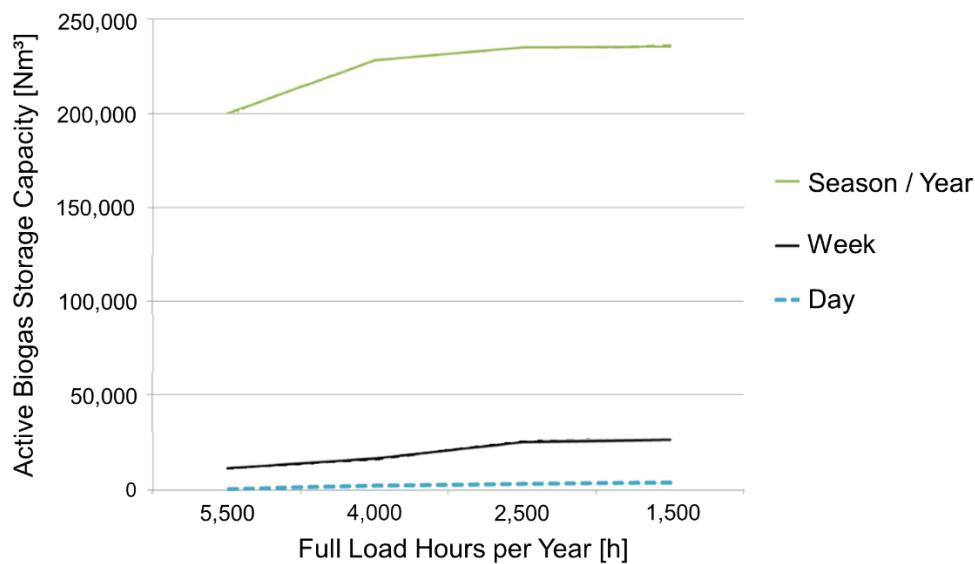


Figure 2.13: Necessary Gas Storage Capacities for Different Demand Considerations (Holzhammer et al. 2013b)

Considering the utilisation of the gas storage capacity of the different temporal courses of demand consideration, it is noticeable that for the coverage of the weekly demand, gas storage fill levels of more than 60 % are rarely reached and the required gas storage capacity could be reduced (Holzhammer et al. 2013b). In contrast, with the consideration of the demand over the year, the gas storage is used more regular (Holzhammer et al. 2013b).

The consideration of weekly residual load fluctuations with flexibilities less than 4,000 full load hours per year leads also to unsuitable gas storage sizes for an in-situ electricity production. In this case, an implementation of a variable gas production would lead to a significant reduction of the required gas storage (Holzhammer et al. 2013b).

If seasonal fluctuations far beyond the week course are to be considered, the classic biogas storage technology seems unsuitable. The requirements would exceed all standard sizes and lead to high technical, financial and regulatory challenges. In this case the biogas supply

should be carried out by the natural gas infrastructure (Holzhammer et al. 2013b). For this purpose, the biogas must be upgraded to natural gas quality and fed into the natural gas grid (cf. chapter 2.1.3). Since the CO_2 in the biogas is almost separated to reach natural gas quality, the necessary storage capacity is reduced by almost 50 %. The natural gas grid is connected with additional natural gas storage capacities, so the processed biogas quantities can be stored for extended periods.

Flexible Gas Production

For feedstock management, the range of energy contents and degradability of various substrates are used. [Figure 2.14](#) shows the specific gas formation rates of various agricultural biogas substrates. They were determined by discontinuous batch experiments (Mähnert 2007). The maximum formation of methane varies between 2 (maize silage) to 6 days (cattle slurry). This implies, that the amount of energy contained in the substrates is available at different times. With this knowledge and corresponding load forecasts the gas production can be adapted to the load theoretically.

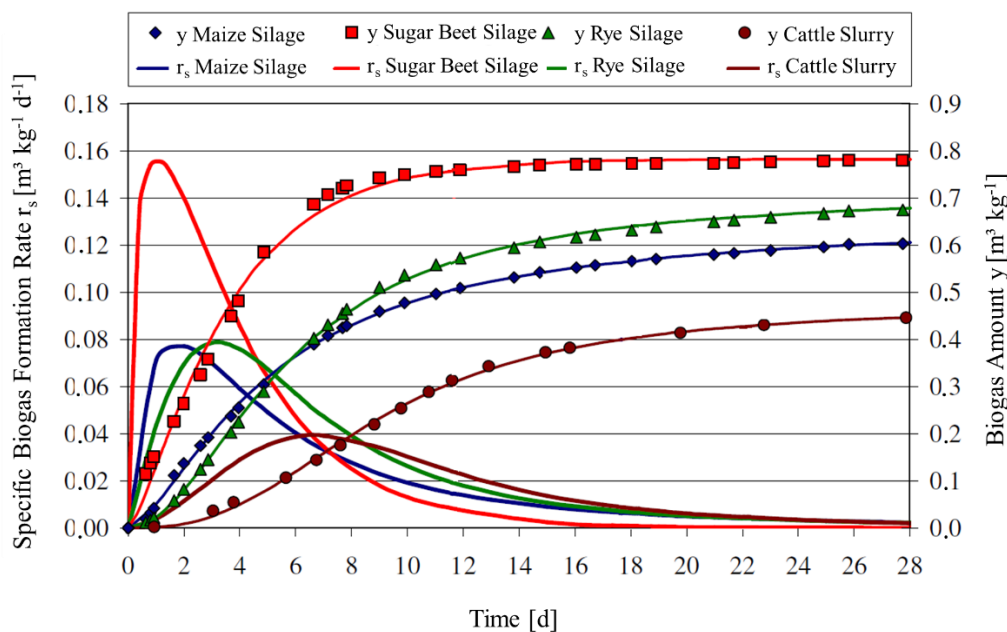


Figure 2.14: Gas Formation Dynamics and Degradability of Different Agricultural Substrates (Mähnert 2007)

In contrast to [Figure 2.6](#) the biogas quantities in [Figure 2.14](#) do not refer to the fresh mass but to the dry mass, whereby the two figures are not directly comparable with each other.

Müller et al. (2011) showed in his experiments that it is possible to adjust the gas production to load profiles. A laboratory digester (reactor volume 10 l) was fed with relatively fast degradable grain residues from ethanol production. It was shown that the feed rates of the laboratory digester could be adjusted, so that the gas formation occurs congruent with a standardised day load profile.

In further laboratory-scale experiments, the substrates maize and sugar beet silage were used with different shares and amounts to adjust the biogas production rate to an electricity price curve in a selected time period. Thereby, a relatively high compliance was achieved, which shows the potential use of the feeding management for a controlled electricity production (Szarka et al. 2013).

Also in laboratory-scale experiments Jacobi (2013) was able to produce 65 to 70 % of the daily amount of biogas within half a day. This means that for a scenario in which the installed electric capacity is operated for 12 h/d the amount of biogas which must be stored can be reduced significantly. If during the interruption of the electricity production only 30 % of the amount of gas is produced which is produced during the electricity production period, the required gas storage volume is reduced by 60 % compared to a continuous gas production (Jacobi 2013).

Another approach of the flexible gas production is given by Mauky et al. (2015) and Mauky et al. (2016). He investigates daily adjusted biogas production rates in continuous processes via variable combination of the substrate feed. Besides laboratory-scale experiments, which indicated a long-time stable process even under highly dynamic conditions, he determined the potential of reducing the gas storage demand via model-based calculations.

Hahn et al. (2014) proved the ability of biogas plants to produce flexible electricity concerning the storage possibilities of biogas and the upgrading to biomethane as well as the flexible production of electricity by controlling the CHPs. Furthermore, they examined the feeding management by adding liquid substrates. Neither the flexibility of CHPs nor the improvement of the overall efficiency is considered.

Grim et al. (2015) investigates the relation between storage requirements and feeding management via a model-based research of demand-oriented electricity production, showing that a suitable feeding management enables a significant reduction of the of the gas storage demand.

However, the results obtained in the laboratory cannot be directly applied on industrial scale. It can be assumed, that large-scale digesters react more slowly to feed-in changes. This is due to the lower mixing as compared to lab-scale digesters (Müller et al. 2011).

Since the organic load in the digesters increases through the variation of the substrate feed-in, the process stability decreases. For this reason, the requirements regarding the biological process monitoring increase (Gerhardt 2009).

According to Gerhardt (2009) the disintegration is a further opportunity to accelerate the anaerobic conversion in order to adapt the biogas production to demand. A pre-treatment of the substrates, as well as a treatment of the digestate after the first stage fermenter is possible. The higher degree of digestibility and the faster anaerobic conversion is reached due to the break-up of fluff-structures or by cell lysis of the microorganisms and the associated enzymatic digestion. This technique originates primarily from the treatment of sewage sludge. With respect to agricultural biogas plants, there has been research (IKTS 2006) but few applications in practice (Gerhardt 2009).

The basis for fixed-bed technology is a separation of the biogas degradation process phases. This makes it possible to optimise the different stages without the impairment of the others.

Through the creation of certain milieus for a first hydrolysis and acidification stage and a second anaerobic methane formation stage in separate reactors, it is possible to create highly reactive biocenosis. This allows higher bioreactor volume loads in the methane formation stage. So a faster biogas production and reduced hydraulic retention time is possible. Very short hydraulic retention times can be achieved, if for the methane formation stage, a digester with a large specific surface (fixed-bed) is used. Thus, flexible biogas production is possible in addition to a very high process stability (Großmann et al. 2008). Experiments of Großmann et al. (2008) and Ganagin et al. (2011) show that fixed-bed digesters are able to switch the methane formation off and on within a few hours.

In practice, large scale fixed-bed digesters are used only sporadically (Großmann et al. 2008, Ganagin et al. 2011). These plants are designed for a continuous production of biogas. In order to produce the same amount of gas as in the case of continuous gas produc-

tion, large tanks for the provision of the digestate from the first process stage and also significantly larger fixed-bed digesters would be necessary. This would lead to a high construction effort and high investments for a controlled gas production by fixed-bed digesters.

2.2.3 Controllable Electricity Production via Biogas in Germany

The German Renewable Energies Acts 2004 and 2009 did not give any incentives for biogas plant operators to produce electricity on demand. This was due to subsidies considering only the amount of electricity, and not the period during which electricity is fed into the grid. Thus, an economic benefit could only be achieved by operating biogas plants with very high CHP usage rates and full load hours. For this reason, conventional biogas plants are currently operated continuously and at a high rate of full load hours.

With the Renewable Energies Act 2012, operators of biogas plants are incited to produce electricity on demand.

These legislative modifications imply the introduction of three premiums to make the placement of electricity on the market attractive and compensate for the investment for additional plant equipment for a demand-driven electricity production. These three premiums are the Market Premium, the Management Premium and the Flexible Premium.

- The **Market Premium** is intended to cover the market price risk. The amount of the market premium is calculated by the difference of the monthly average price on the day ahead spot market of the EPEX SPOT SE and the fixed EEG feed-in tariff.
- The **Management Premium** is intended to cover the marketing efforts and is subjected to an annual depression. In 2012, the Management Premium was EUR 0.003 per kWh.
- The **Flexible Premium** is intended to cover the investment for additional plant equipment such as higher power generation capacity and additional gas storage necessary for the flexible and controlled electricity production. The amount of the premium is EUR 130 per year for each additionally installed kWel. The premium is paid for 10 years.

Higher payments for electricity are already possible without a flexible operation (i.e. without Flexible Premium), by using the Market Premium and the Management Premium.

With the installation of additional power generating capacities, the Flexible Premium can also be used.

Since the Market Premium is calculated using the monthly average price on the day ahead spot market of the EPEX SPOT SE, additional revenue can be achieved by shifting the electricity production from low-priced periods to high-priced periods.

In mid 2013, 21 % of the German biogas plant operators used the market premium and the management premium (Nelles et al. 2013). Since a higher revenue is possible without changes in the electricity feed-in, it is not possible to draw conclusions whether the electricity production is operated demand oriented or not. At the same time the flexible premium was requested by only 3 % of the market premium users (Nelles et al. 2013). However, it is unknown in which way and for which purpose these biogas plants are operated in general.

Most of the biogas plants which use the Flexible Premium utilise existing oversized electricity production capacities. Also, a heat production led operation of the biogas plant entitles to the usage of these premiums, if more electricity production capacity is installed as compared to the average produced amount of electricity.

2.3 Chapter Summary

Biogas can be a key technology within the renewable energies in the future, since only biogas has the ability to be stored and to produce electricity on demand. So biogas will produce high-quality electricity when it is needed, instead of base load electricity as in most cases today.

The complexity, which must be taken into account within the controllable electricity must be underlined. In addition to the stability of the biological process, the costs represent a major discussion point for future systems. To achieve an economic optimum for corresponding concepts, suitable components, efficient control strategies and system configurations must be chosen.

In some cases, very high flexibilities of the electricity production via biogas plants were investigated (e.g. Hartmann et al. (2010), Holzhammer et al. (2013b)). Flexibilisations which are exceeding three times of the rated power and gas storage volumes exceeding 24 times the amount of gas, produced in one hour, does not seem to be practicable for short-term measures that can be implemented in conventional biogas plants.

Larger Capacities and larger gas storages can be made available via the upgrading of biogas to 'biomethane' and the injection into the natural gas grid. However, for agricultural biogas plants the access to the gas grid is rarely possible.

By means of a flexibilisation of the gas production, a reduction of the necessary gas storage volume is possible. However, such developments and applications are not available beyond the laboratory scale. All data relating to cost and storage reduction are therefore based on simulations and assumptions.

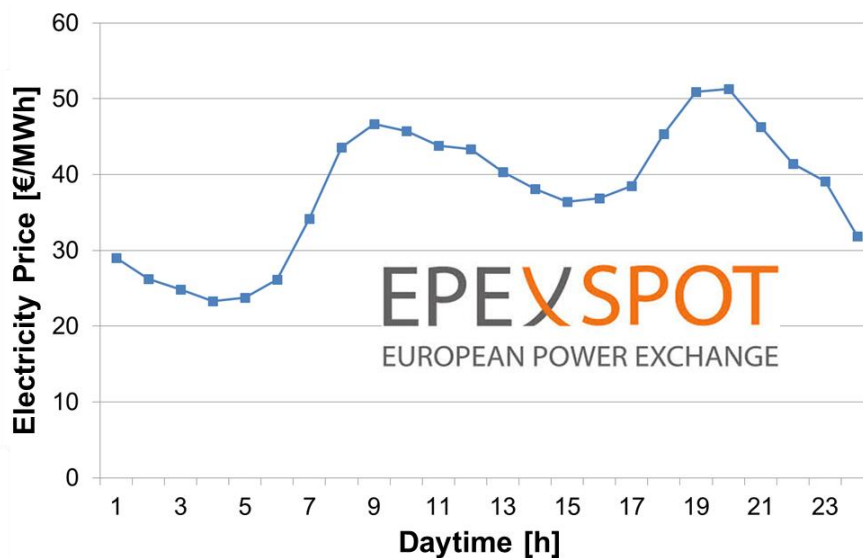
Therefore, the In-situ storage of biogas seems to be the best concept for a short-term, cost efficient and feasible possibility. Scientific work regarding a tangible implementation of such concepts are not known.

The examination in the following sections are complementing the existing academic literature with highly feasible plant concepts for agricultural biogas plants including the design the affected components, description of control strategies and an implementation of a corresponding concept.

3 Technical Analysis

Conventional biogas plants are currently operated continuously at full load (base load operation), independent of any kind of demand.

For the flexible electricity production, biogas plants have to act in accordance with the demand of the electricity grid. The most important instrument for this purpose in Germany is the electricity market, in particular the Day Ahead Auction of the EPEX SPOT SE. The EPEX SPOT is a European market place for electricity. [Figure 3.1](#) shows the average hourly electricity price of the Day Ahead spot market in Germany/Austria of 2013. The course of the electricity prices is also representative for 2017.



[Figure 3.1](#): Average Hourly Electricity Price 2013

The prices of the Day Ahead Auction are determined by supply and demand for each hour of the following day. Thus, plants which are operating according to this price signal are operating in accordance to the demand of the electricity grid. This way, higher revenues in comparison to the base load-operation can be achieved by shifting the electricity production from low-price periods (during the night and lunch time) to high price periods (morning and evening).

To vary the electricity production, higher generation capacities as for a base load-operation, have to be installed. Additionally, the biogas plants must be able to shift the utilisation of the biogas, i.e. the plants must be able to provide the gas at high-priced times. A time based operational schedule can be implemented in the internal control system.

Many biogas plants are suitable for a flexible electricity production. By using biogas storages, the biogas production can be decoupled from the power generation. Thus, the schedule for the feeding management does not have to be changed significantly. With these technical pre-requisitions the required amount of biogas can be adapted to the demand of the electricity grid.

To produce as much electricity as possible during times of high prices on the electricity market, the temporarily stored amount of biogas has to be utilised with higher electrical power capacities and during shorter operating periods than in base load-operation.

This leads to new requirements for the components of the gas storage, gas processing, gas utilisation and heat utilisation.

In the following, the current state-of-the-art of the affected components as well as the requirements and technical recommendations of components associated with controllable electricity production are described. This is the basis for the further concept development.

3.1 State-of-the-Art of Affected Components

Figure 3.2 shows a simplified typical layout of a biogas plant at base load operation consisting of a digester, gas pipe system, gas cooling system, compressor, CHP unit and transformer which is the connection to the power grid.

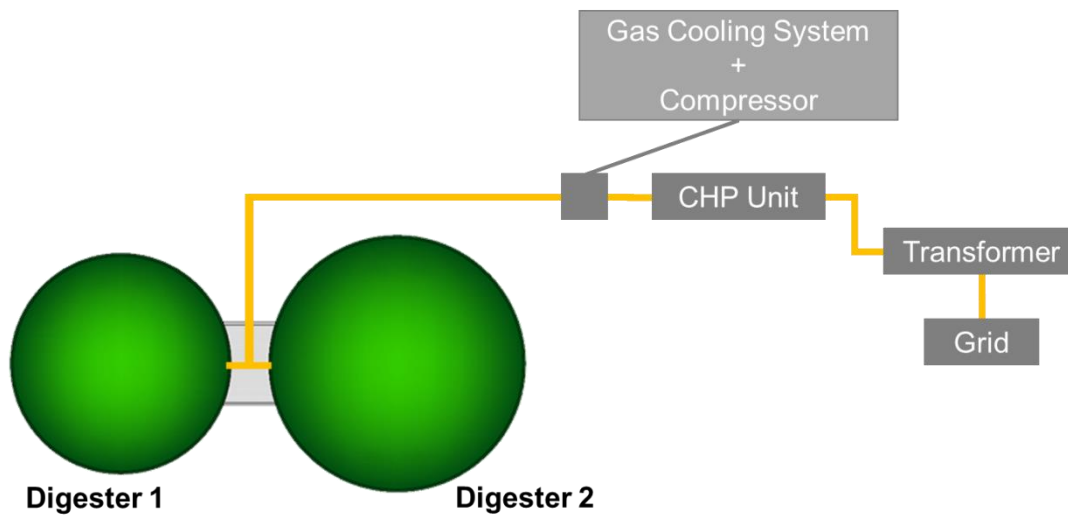


Figure 3.2: Layout of a Biogas Plant with Base Load Operation

For a biogas plant with controllable electricity production, various modifications are required. Approaches are additional gas storage facilities in order to achieve a shift of the biogas production. This can be, for example, the storage of biogas over a period from 6 to 24 hours. Therefore, the capacity of the electricity generation facilities has to be increased to use the stored biogas in less time.

The gas pipe system, connecting the gas storage and the CHP units, has to be adapted for the increased gas flow. In particular, the gas cooling system and the gas compressor have to be adjusted.

A simplified typical layout of a biogas plant with controllable electricity production is shown in Figure 3.3.

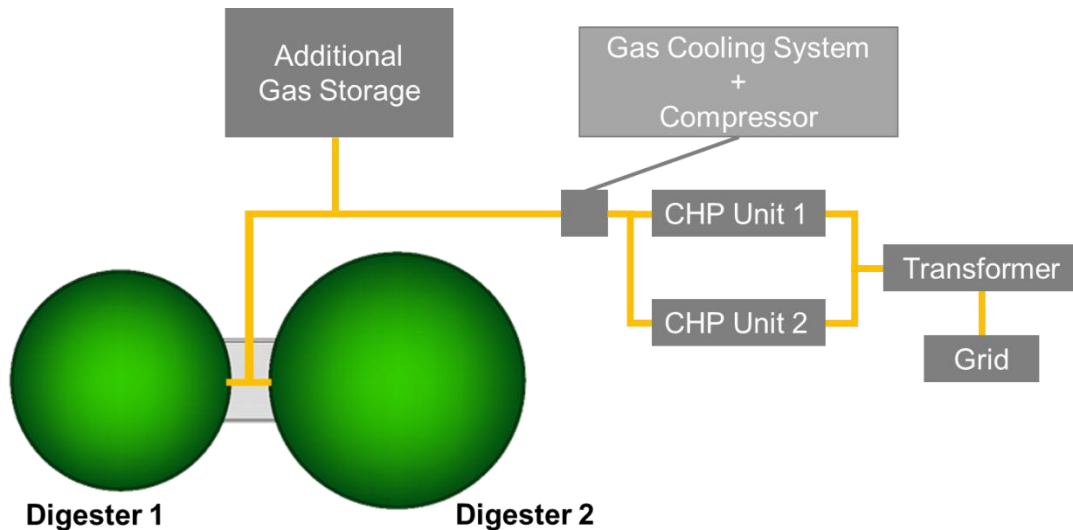


Figure 3.3: Layout of a Biogas Plant with Flexible Electricity Production

3.1.1 Gas Storage

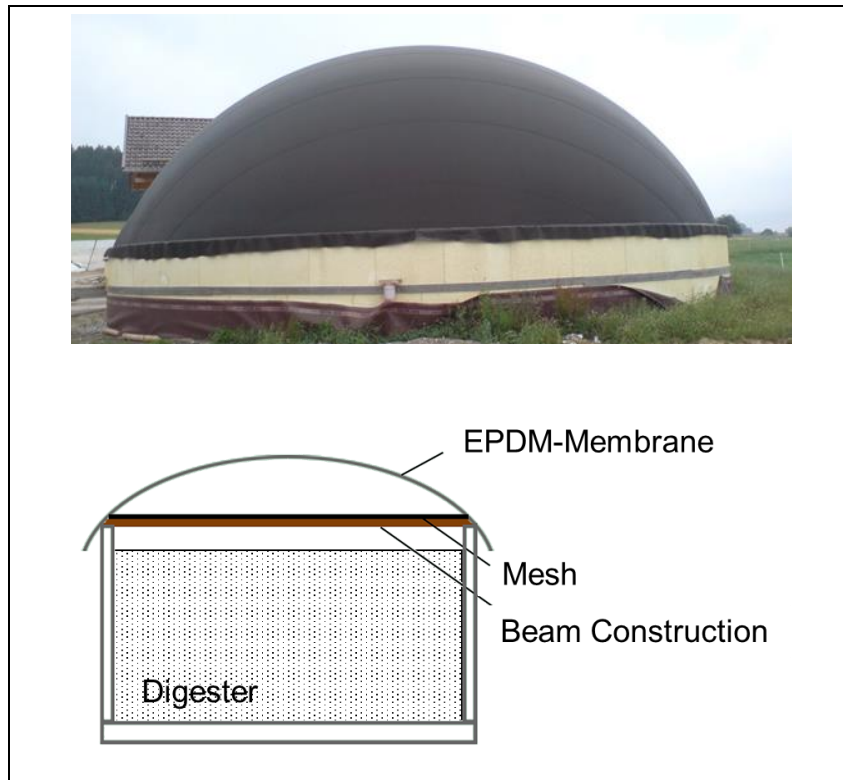
The most common way of storing biogas is in the gas tight coverings of digesters and residue storage tanks (internal gas storage). The average storage capacity of biogas plants in Germany is about 25 % of the daily produced amount of biogas. 30 % of the German biogas plants have additional biogas storage facilities such as external gasholders (Fachagentur Nachwachsende Rohstoffe e.V. 2009). Important for the operation of biogas storage systems is their fill level monitoring.

3.1.1.1 Internal Gas Storages

For the internal gas storage foils as covers above the containers are used. These are supported by a pillar in the centre of the tank or by gas pressure. The foils are attached to the top edge of the tanks and sealed by locking systems. Single layer systems and double layer systems with one foil for the gas storage and one foil for the weather protection are used. The gas is usually stored within a pressure range from 0.5 to 30 mbar. In order to avoid contact between substrate in the tank and the gas storage, a pillar supported mesh or beam construction is installed. The most common internal gas storage technology is the air supported double layer system (Fachagentur Nachwachsende Rohstoffe e.V. 2010).

Single Membrane Systems

Single membrane systems are used at about 20 % of the biogas plants in Germany. The typical foil used is made of ethylene propylene diene monomer (EPDM). The biogas inflates the foil and expands it. The construction of single membrane systems is shown in [Figure 3.4](#).



[Figure 3.4](#): Single Membrane Gas Storage

Double Layer Systems – Pillar Supported

The two foils are fixed at the top edge of the tank and at a pillar in the centre of the tank. The outer membrane is stretched and protects the inner membrane from the weather. A mesh protects the inner membrane from touching the substrate in the digester. The actual gas storage takes place under the inner membrane. As shown in [Figure 3.5](#), the useable volume is limited by the shape of the outer membrane and the mesh.

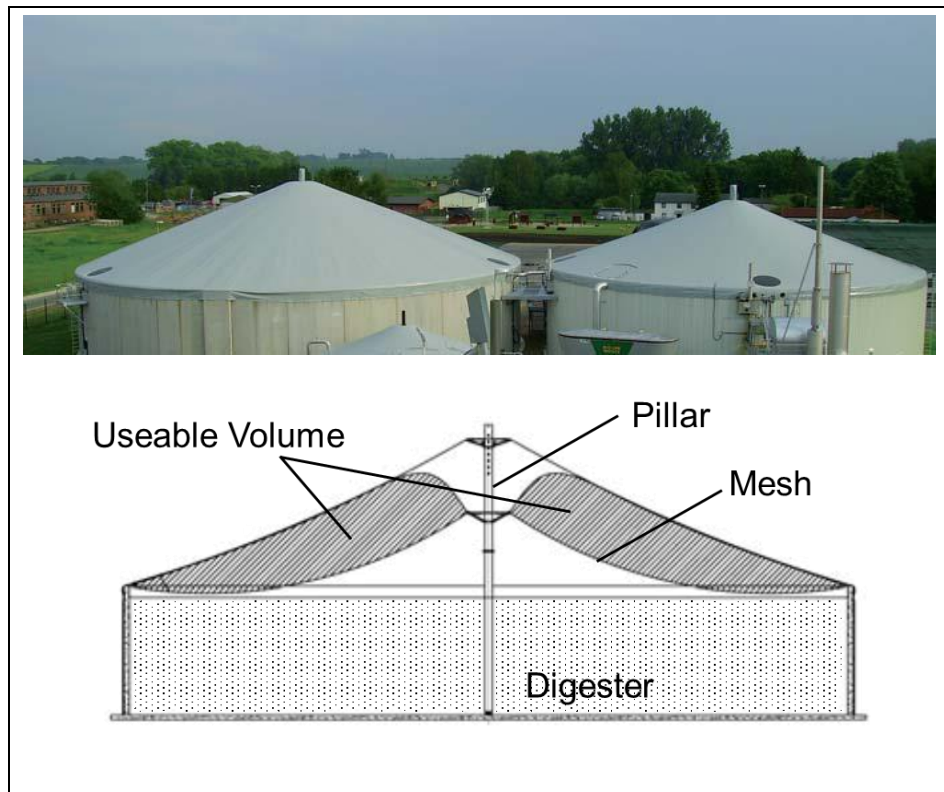


Figure 3.5: Pillar Supported Double Layer Gas Storage (Ceno n.d.)

Double Layer Systems – Air Supported

Air supported double layer systems consist of an inner membrane for the gas storage and an outer shaping membrane for the protection against external influences (Figure 3.6). The shape and stability of the outer membrane is realised by the supporting air, blown through an air blower into the space between the outer and inner membrane. This supporting air causes a constant pressure at the inner gas storage membrane and the stored biogas. In response to changing gas volumes, the pressure is permanently regulated via outlet valves. Internal double membrane gas storages are usually designed as $\frac{1}{4}$ or $\frac{1}{2}$ spheres. Especially $\frac{1}{2}$ spheres provide large storage volumes.

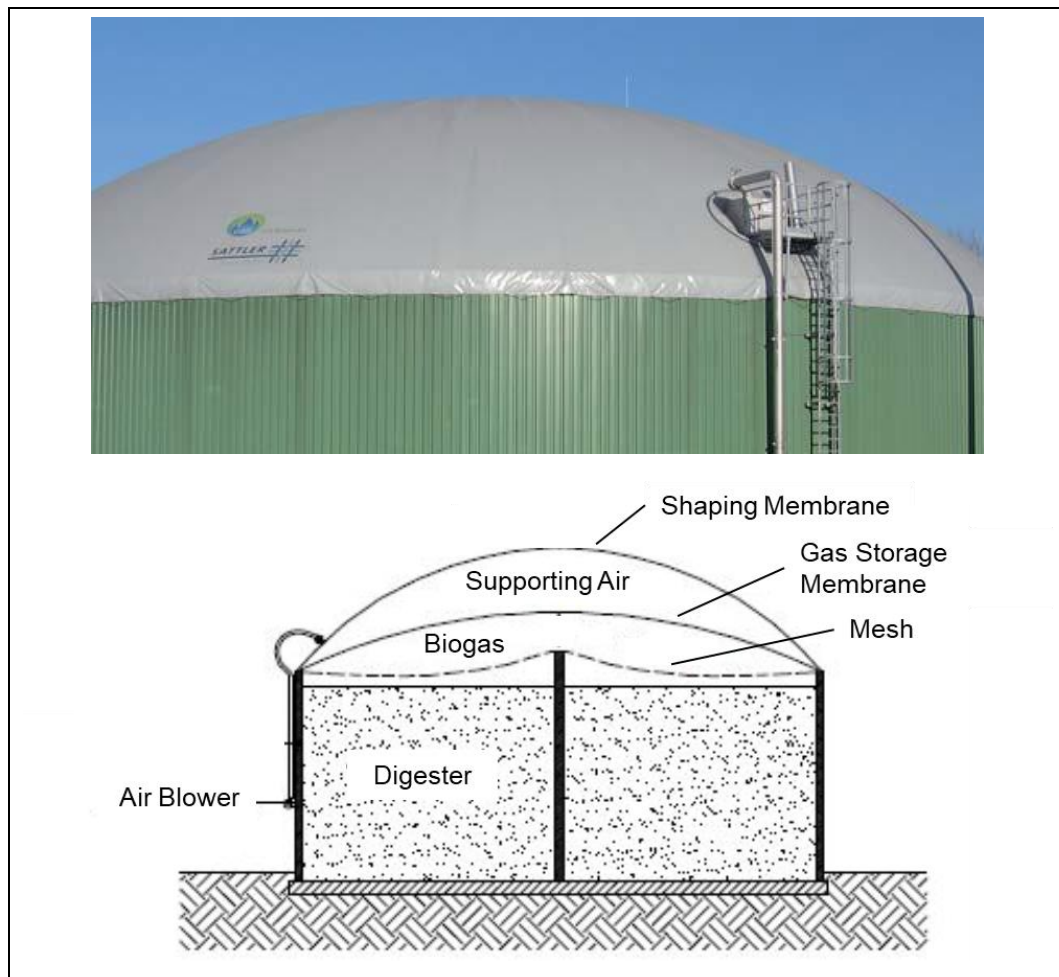


Figure 3.6: Air Supported Double Layer Gas Storage (BLU 2007)

3.1.1.2 External Gas Storages

For the external gas storage, different systems are common. Membrane gas reservoirs, air supported double layer systems as well as dry-seal gasholders are used.

Membrane Gas Reservoirs

Membrane gas reservoirs as shown in [Figure 3.7](#) enable the use of dead space in buildings for the storage of gas. It is also common to hang up membrane gas reservoirs in large cylindrical buildings. Unfortunately the storage pressure of such gasholders cannot be adjusted, hence, gas storage management is not possible.

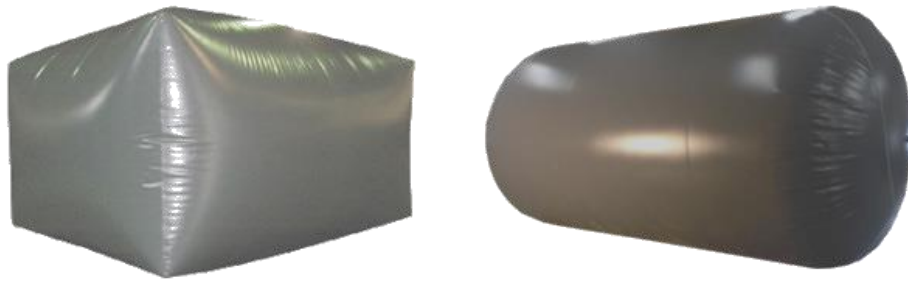


Figure 3.7: Exemplary Designs for Membrane Gas Reservoirs (Foliengasspeicher n.d.)

Double Layer Systems

External double layer systems are made like internal air supported double layer systems by an air supported outer membrane and a moving inner membrane for the storage of gas. These gasholders are usually designed as $\frac{3}{4}$ spheres (Figure 3.8). The design allows large storage volumes and operating pressures up to 30 mbar. With increasing volume the possible operating pressures decrease (Ceno n.d.).



Figure 3.8: External Air Supported Double Layer Gas Storage (Ceno n.d.)

3.1.1.3 Fill Level Monitoring

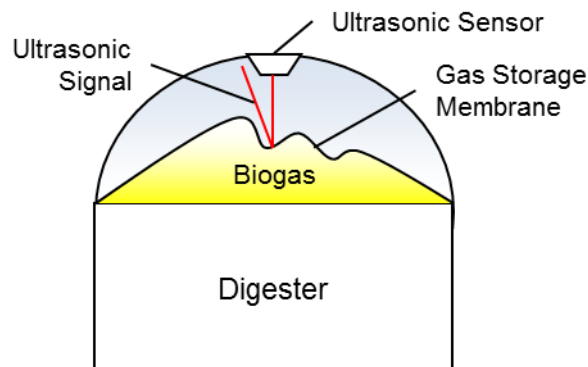
For the fill level monitoring of biogas storages various systems are in use. Since the storage of biogas in general takes place through volume changes and not through pressure changes, it is the objective of the fill level monitoring to measure the position of the gas storage membrane. Therefore, non-contact systems, rope systems and water level gauge systems are in use. Due to the low storage pressure and changing flow conditions inside and outside the gas space as well as external loads, i.e. wind, the position of the gas storage membrane is at random. These characteristics regarding the position of the inner

membrane cause considerable challenges for fill level measurement systems, which must be taken into account in the assessment of the accuracy of the systems.

Non-Contact Systems

Non-contact systems measure the distance between a defined point and the gas storage foil via an ultrasonic signal. These systems are usually not used for digester-mounted systems like air supported double layer systems. The reason for this is, that the inner membrane supplies no defined reflection point for the ultrasonic signal, due to folds and bulges within the gas storage membrane (cf [Figure 3.9](#)).

For $\frac{3}{4}$ spherical shape air supported double layer systems this technology can be used, since the inner membrane can be designed in the way that it moulds in a defined manner.



[Figure 3.9](#): Schematic Representation of Fill Level Monitoring Systems via an Ultrasonic Signal

Rope Systems

Rope systems measure the position of the gas storage membrane by using a rope which is stretched over the foil. The rope finally ends over deflection rollers in a measuring tube. Each change of the inner membrane position leads to a length variation of the rope in the measuring tube ([Figure 3.10](#)). At the end of the rope is a magnet, which operates reed switches.

The accuracy and reliability of this measurement method is low, since the membrane can sag under the stretched rope and bulges next to the rope cannot be detected. Another weakness is the low resolution of the signals produced by the reed switches.

This measuring system is also very susceptible to failure due to its mechanical design. For example the rope can get stuck, making this solution unsuitable.

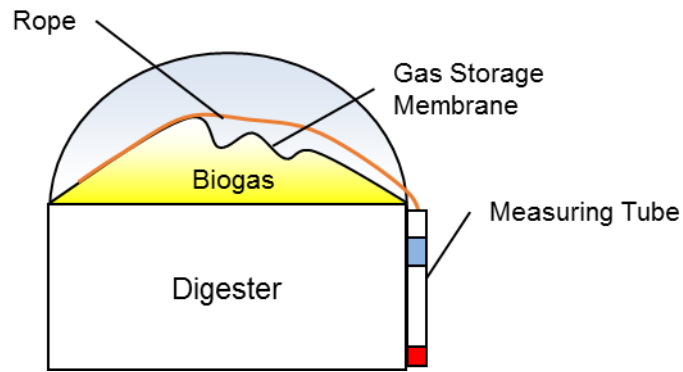


Figure 3.10: Schematic Representation of Fill Level Monitoring Systems via a Ropes

Water Level Gauge Systems

State-of-the-art fill level monitoring systems for air supported double layer systems are water level gauge systems (Figure 3.11).

A fluid-filled tube is fixed at a defined position of the inner membrane. When the inner membrane position is changing, the hydrostatic pressure at the opposite end of the tube alternates. This change in hydrostatic pressure is measured and the position of the defined measuring point can be detected.

A major benefit of this system is that several water level gauge systems can be installed at the inner membrane (Figure 3.11). This allows a good consideration of the membrane moulding.

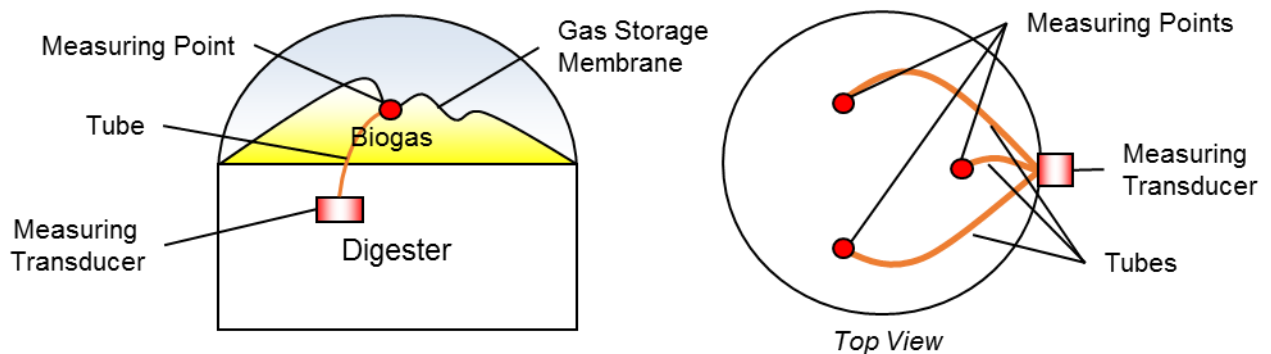


Figure 3.11: Schematic Representation of Fill Level Monitoring Systems via a Water Level Gauges

In comparison to other measurement methods, most reliable results can be achieved with hydrostatic tube scale systems (Ceno n.d., Tenbrink 2013).

3.1.2 Gas Conditioning

The biogas in the digesters is saturated with water vapour and contains considerable quantities of hydrogen sulphide (H_2S) in addition to CH_4 and CO_2 . In compound with the water vapour contained in the biogas, H_2S forms a sulphuric acids. These acids affect the biogas utilisation units as well as upstream and downstream components (gas pipes, exhaust pipes etc.). For these reasons, the biogas is desulfurized and dried.

3.1.2.1 Desulphurisation

In about 85 % of the biogas plants desulfurization is carried out directly in the fermenter by air injection (Deutsches Biomasse Forschungszentrum 2012). In this method, the H_2S in the biogas is transformed into elemental sulphur through the presence of oxygen. The required oxygen is provided by the injection of small amounts of air. With this method H_2S contents of 50 to 2,000 ppm are reached.

In order to ensure low levels of H_2S a desulfurization via adsorption on activated carbon is used. With this method purities less than 5 ppm H_2S are possible. Activated carbon filters are used especially for power generation units larger than 500 kW_{el} (Deutsches Biomasse Forschungszentrum 2012).

3.1.2.2 Gas Drying

Condensation drying is common in biogas plants. The functional principle of this procedure is based on the separation of condensate by cooling the biogas below its dew point. The cooling of the biogas is usually carried out in gas pipes. In this case a section of the gas pipe is buried under the ground. Necessary is a sufficient length of this section. The achievable temperature drop depends on the soil temperature.

Another possibility for cooling the gas are electric cooling units. The cooling is achieved by heat exchangers, where cold water circulates. With this method dew points from 3 to 5 °C can be reached. The cooling units must be designed for the volume flow which has to be dried. With the conventional base load electricity production this method for the drying of gas is recommended for electrical capacities above 300 kW_{el} due to economic and technical reasons (Zörner et al. 2010).

3.1.3 Combined Heat and Power Production

As described in chapter 4.1.3, for the electricity production at biogas plants, combined heat and power production is carried out via reciprocating engines (Fachagentur Nachwachsende Rohstoffe 2010).

Most important components of the CHP units are the combustion engine, the generator and the heat extraction.

3.1.3.1 Combustion Engines

For the utilisation of biogas, technically adapted spark-ignited and ignition oil engines are used (see chapter 4.1.3). From today's perspective, combustion engines for biogas are very well developed. The efficiencies are comparable to those of diesel engines (Herdin 2002).

Spark-Ignited Engines

Spark-ignition engines are specifically designed for gas operation. They work according to the Otto principle. The motors are operated as lean-burn engines with high excess air to minimize nitrogen oxide emissions.

In lean operation, less fuel in the engine can be reacted which, however, leads to a reduction in performance of the motor. This is compensated by charging of the engine by means of exhaust gas turbochargers.

Spark-ignition engines require a minimum content of methane in the biogas of about 45 % (Fachagentur Nachwachsende Rohstoffe 2013). At lower methane contents they switch off.

Essential key figures of spark-ignited engines are shown in [Table 3.1](#).

Table 3.1: Key Figures of Biogas Spark-Ignition Engines
(Fachagentur Nachwachsende Rohstoffe 2013)

Electric Power	up to > 1 MW
Efficiency Factor (electric)	34-42 %
Service Life	ca. 60,000 h

Ignition Oil Engines

Ignition oil engines operate on the diesel principle. The biogas and the combustion air is mixed in a gas mixer. The ignition takes place via an ignition oil which is supplied in the combustion chamber via an injection system.

Also ignition oil engines are operated with high excess air. The proportion of the ignition oil is usually approximately 2-5 % of the supplied fuel capacity (Fachagentur Nachwachsende Rohstoffe 2013). Table 3.2 shows the key figures of ignition oil engines.

Table 3.2: Key Figures of Biogas Spark-Ignition Engines
(Fachagentur Nachwachsende Rohstoffe 2013)

Electric Power	up to 340 kW
Efficiency Factor (electric)	up to 44 %
Service Life	ca. 35,000 h

3.1.3.2 Generators

Another central component of a CHP unit is the generator, which converts the mechanical energy generated by the combustion engine into electrical energy. In CHP units asynchronous and synchronous generators are used. With biogas plants, synchronous generators are usual. Asynchronous generators are solely used in biogas CHP units below 100 kW_{el}. During the start process of the CHP units, synchronous generators must first be brought into line with the grid frequency by a synchronizing device. After the binding of the generator to the grid, the load of the engine can be increased continuously.

With present generators, the mechanical energy from the engine can be converted to electric energy with an efficiency of 95-97 % (Zacharias 2001).

3.1.3.3 *Heat Extraction*

At CHP units, the heat can be extracted from the engine cooling water circuit, the exhaust gas stream and the charge air cooling. Depending on the engine, about 40 up to 45 % of the heat are in the exhaust stream.

The engine cooling water temperatures for the cooling of the engine and the charge air cooling are about 80 to 90 °C. For the extraction of the heat usually plate heat exchangers are used.

The temperature level of the exhaust stream varies from 400 to 600 °C. The heat is primarily extracted by means of tube bundle heat exchangers made of stainless steel.

Because of the high temperature level of the exhaust stream it is possible to extract heat at a much higher temperatures for hot water above 90 °C and even for raising steam.

The thermal efficiency of CHP units is slightly higher than the electric efficiency and varies between 40 and 45 %.

3.2 Component Requirements and Technical Recommendations

To produce as much electricity as possible during times of high demand, the temporarily stored amount of biogas has to be utilised with higher electrical power capacities and during shorter operating periods than in base load-operation.

In the following the differing requirements for the components of the gas storage, gas processing and gas utilisation, which are entailed with the changed operation for the controllable electricity production are described. The evaluated technical possibilities on component level serve as a basis for the further concept development.

3.2.1 Gas Storage

Gasholders are currently intended to compensate a fluctuating biogas production and to store the produced biogas during planned and non-planned maintenance. For this application neither the gas storage capacity nor the accuracy of the fill level monitoring are very important.

In the case of a demand oriented electricity production the available actual usable gas storage volume (lung-volume), the accuracy of the fill level monitoring and the possibility of the combination of several gasholders to increase the total lung-volume (gas storage management) are relevant.

3.2.1.1 *Standardisation of the Gas Volume*

For the operation and control of the demand oriented electricity production via biogas plants, the recording of the available amount of biogas and its energy quantity is very important. Since the volume of a gas depends on temperature and pressure, it is necessary to refer the volumes to standard conditions. Hence, a comparison of biogas yields, volumes and stored amounts of energy can be carried out.

For dry gases, the standard volume can be calculated according to (1):

$$V_s = \frac{V \times T_s \times p_G}{T \times p_s} = \quad (1)$$

with: V_s = standard volume of the gas [Nm^3]

V = actual volume [m^3]

T = temperature of the gas [K]

T_s = standard temperature (273.15 K)

P_G = absolute pressure of dry gas [bar]

p_s = standard pressure (1.01325 bar)

For internal gas storage the biogas is usually saturated with water vapour, the water content of the biogas must be considered in order to determine the stored amount of energy. For this purpose, the absolute pressure of the gas storage has to be reduced by the partial pressure of the dry biogas (2).

$$p_G = p_{abs} - \varphi \times p_p \quad (2)$$

with: p_{abs} = absolute pressure in the gas storage [bar]

φ = relative humidity in the biogas [%]

P_p = partial pressure of water vapour [bar]

According to (1), the gas temperature has a significant influence on the storable standardised volume. The gas temperature in the gas storage depends on several factors such as the ambient temperature, the type of digester where the gas storage is located (heated or non-heated digester) and how the solar radiation affects the gas storage. Double layer gas storages minimise the ambient influences and bright coloured outer membranes can reduce the influence of the solar radiation.

3.2.1.2 Gas Storage Management

The gas storage management is very important for the controllable electricity production by biogas plants. In contrast to a continuous biogas production, electricity is produced discontinuously. Due to this, the gas storage is filled and deflated again and again.

To produce electricity on demand the produced amount of biogas, the stored amount of biogas and the demand for biogas of the CHP unit(s) have to be known at any time.

Aim of the gas storage management is the monitoring and control of several gas storages.

On biogas plants, the gas storage often takes place at multiple locations. Internally in different tanks or in external gas storages. Depending on the prevailing conditions at the individual gas storage, the gas expands differently and flows to the point of the lowest pressure level in the storage system.

It is recommended to store most of the biogas near the CHP units. Thus, a reliable and sufficient amount of biogas is available and can be used for a controlled electricity production.

For this reason, a pressure cascade has to be created. In this pressure cascade the lowest system pressure should be at the gas storage which is nearest to the CHP units. For this purpose gas storage systems such as air supported double layer systems which are able to vary the pressure in the gas storage are most suitable.

3.2.1.3 Fill Level Measurement for Gas Storages

For the record of the stored amount of energy in the gas storages besides the composition, the temperature, the pressure and the volume of the stored biogas have to be known. As described in chapter 3.1.1.3, the fill level measurement takes place via the measurement of the position of the gas storage membrane. The various gas storage systems differ in their possibility to determine the fill level.

The monitoring of the fill level of single membrane systems made of EPDM is limited. For the structural stability of the covering, the gas storage should be inflated at any time. Thus, the amount of stored gas can only increase through minor pressure changes and the associated elastic elongation of the membrane. Due to many influencing environmental factors such as solar radiation on the membrane, the fill level measurement is difficult and not accurately possible.

The motion of the gas storage membrane of pillar supported double layer systems is limited by the fixing of the membrane at the edge of the tank and the support pillar. Thus, only small position changes of the membrane are possible which make it difficult to determine their position. Through the sagging of the inner membrane it is only possible to give statements whether the gas storage is completely empty or full via the pressure in the gas space.

In contrast to other gas storage technologies the fill level of air supported double layer systems can be monitored quite well. This is due to the very mobile gas storage membrane. Via the pressure in the gas space only statements regarding the extreme values are possible.

As described in chapter 3.1.1.3, water level gauge systems are state-of-the-art for double layer systems and the most reliable results can be achieved with this technology. The random position of the gas storage membrane can be handled by using 2 or 3 water level gauges located regarding the individual gas flow in the gas storages ([Figure 3.11](#)). Thus, measuring accuracies between 90 % (Holzhammer et al. 2013c) and 95 % (Tenbrink 2013) are achievable.

3.2.1.4 Evaluation of Different Gas Storage Technologies

Very important for the controllable electricity production by biogas plants is the suitability of gas storage technologies. Important factors for the storage of biogas are the usable volume, the monitoring of the gas storage fill level and its ability for gas storage management. Within [Table 3.3](#) the different discussed gas storage technologies are evaluated regarding this challenges.

Table 3.3: Evaluation of different gas storage technologies

Gas Storage Technology	Usable Volume	Fill Level Monitoring	Gas Storage Management
Single Membrane Systems (EPDM)	0	0	-
Pillar Supported Double Layer Systems	0	0	-
Air Supported Double Layer Systems	+	+	+
Air Supported Double Layer Systems (external)	+	+	+
Membrane Gas Reservoirs (external)	+	0	0
Not Suitable	-		
Limited Suitable	0		
Suitable	+		

As the comparison shows, internal and external air supported double layer systems are most suitable for controlled electricity production by biogas plants. They enable the largest usable storage volumes and the most accurate fill level measurement.

3.2.2 CHP

In general, a flexible biogas utilisation can be achieved in two different ways. One option is the intermittent operation of CHP units at its nominal load, the second option is the part load operation of CHP units.

Present engines of biogas CHP units are highly developed and optimised for an operation with biogas. Conventional CHP units in Germany are, due to the previous funding structure (Renewable Energies Act of the years 2000, 2004 and 2009), adapted to a base load-operation and optimised for a high number of full load hours at nominal load (ASUE 2010, Engelhard 1999). Modern gas engines for biogas achieve a service life of about 60,000 h. With the controllable electricity production the original design conditions have changed.

The changed operational mode is accompanied with increased requirements on the engines impacts on their service life and efficiency. Therefore, the two options intermittent operation or part load operation have to be discussed.

3.2.2.1 Intermittent Operation

The intermittent operation is defined as an alternating operation of the engine between standstill and operation at nominal load. CHP units with combustion engines are well suited for an intermittent operation. They can be kept permanently on standby and allow fast response times. The intermittent operation can be carried out according to a defined operating schedule at specific times, on short-term price signals or short-term needs.

A start–stop-operation, however, causes higher material stress to the CHP units than a nominal operation. At nominal load, the engine operates in its optimum range and has the highest efficiency and minimal wear. During combustion high temperatures arise in the combustion chamber, which lead to stress for the engine-components. In nominal load operation stable operating conditions are reached. The parts and components are designed for these stable conditions. During the start the components are still cold and the necessary lubrication to minimise friction does not yet exist. With the beginning of the combustion the materials are exposed to high temperatures. At the start components such as cylinders, cylinder heads, pistons and the exhaust system are stressed with temperature differences, which lead to tensions in the materials and different gaps between the parts (van Basshuysen and Schäfer 2004). This leads to friction, which is increased due to an insufficient lubrication at the beginning.

Due to the intermittent operation of CHP units higher amounts of condensate can occur. Frequent cold starts and the resulting hot gases get in contact with cold component surfaces and lead to this higher amount of condensate. The condensate must be removed by suitable condensate traps to avoid corrosion and other defects.

To prevent the engine from a permanent changing of the load through the intermittent operation and to achieve a high service life and operating safety of the CHP units, the CHP manufacturers demand minimum runtimes per start. The specifications from the manufacturers are very different and vary between 1.5 operating hours (personal communication, MTU Onsite Energy GmbH on 25th May 2012) and 12 operating hours (GE Jenbacher 2012) per start. In general, it can be said, the bigger the engine the longer the minimum runtime per start. However, the intermittent operation of biogas CHP units is a relatively

new area of application for the manufacturers, which inhibits statements regarding minimum runtimes in more detail yet.

As a result of the intermittent operation, the unfavourable operating conditions lead to a lower service life of the engines, a reduced efficiency and an increased maintenance effort. Moreover, additional exhaust emissions and, if ignition oil engines are used, an increasing ignition oil demand must be expected during the starting and shut-down process. A complete avoidance of the loads during start and shut-down is not possible. Supportive measures by using auxiliary equipment, as described in chapter 3.2.2.2, can decrease these influences significantly.

3.2.2.2 Auxiliary Equipment for a reliable Start of CHP units

Important auxiliary equipment to achieve a long service life and reliable starts with an intermittent operation of CHP units are pre-heating and pre-lubrication of the engine. In many modern CHP units these devices are already used. Auxiliary equipment lowers resistances during the start and leads to better combustion-conditions (van Basshuysen and Schäfer 2004).

Pre-Heating

The pre-heating of the engine is an effective way to minimise stress during the start.

The engine components and the lubricant are heated up to a temperature of about 56...60 °C before it starts (GE Jenbacher 2012). This is done to ensure a proper viscosity of the lubricant and to avoid temperature differences among the engine components. The cooling water circuit of the CHP unit is used for this (Zacharias 2001).

The necessary effort is limited to the installation of a heat source, components for the cooling water circuit (ability to use this circuit for heating as well) and the integration of the components into the engine control unit. One heating source can be heating rods, embedded in the cooling circuit. Heating storages in the heating circuit of the biogas plant or the process heat can also be used as heat source. Existing engines can be retrofitted easily. Compared to the overall investment for a CHP unit the cost of additional pre-heating is low.

The required operating time of the pre-heating depends on the mode of operation of the CHP unit, the duration of downtimes between the operating cycles and the available heating power. According to manufacturer requirements, downtimes lower than 2 h usually require no pre-heating. In this case the engine is still at sufficient temperature. The strategy of pre-heating can be either a permanent warming or can take place by periodically pre-heating according to a defined schedule.

The operating cost is limited to the additional electricity consumption. According to the manufacturers, the additional electrical power varies between 3 and 12 kW_{el}. The major part of the electricity demand requires the heating rod. The power consumption of heating rods varies from 1.8 kW_{el} up to 10 kW_{el}, where higher electrical power consumptions imply shorter operation times of the pre-heating.

Pre-Lubrication

A further auxiliary equipment for stress reduction of intermittent operation is pre-lubrication. An electric pump (separate oil pump or an additional one parallel to the main oil pump) ensures the necessary oil pressure before the engine starts. Thus, an oil film can be formed. This way mixed friction is avoided. A post-lubrication is also recommended to lubricate running components such as the turbocharger after the shutdown. Also a slow cooling of hot components can be ensured (GE Jenbacher 2012).

The required capacity of the pump depends on the size of the CHP unit. According to manufacturers, the power consumption of oil pumps can be between 2 and 5 kW_{el}. CHP units up to 500 kW_{el} usually do not need any pre-lubrication, according to manufacturers' information.

3.2.2.3 Starter Systems

Frequent starts cause higher stress for the starter components of the CHP units. Usually, battery powered starter systems are in operation (Zacharias 2001). A reliable start can be achieved by providing high starting speeds (van Basshuysen and Schäfer 2004).

As an alternative, grid driven starter systems can be used. In this case, the engine is started by utilising the power from the electricity grid. The advantage of such systems is a higher starting speed of about 20 % in comparison to battery powered systems (van Basshuysen and Schäfer 2004).

3.2.2.4 *Recommendations for a Reliable Starting Performance*

To guarantee a reliable starting performance the following aspects shall be considered:

- optimum stand-by conditions of the engine (pre-heated and pre-lubricated),
- high starting speeds,
- high methane content of the biogas,
- low water content of the biogas,
- constant gas composition between the starts,
- guaranteed availability of gas.

In addition to an optimum function of the system and control components, a high methane content of the biogas is desirable. As mentioned in chapter 4.1.2, the methane content of biogas varies between 45 and 64 %. According to CHP unit manufacturers, a methane content of at least 50 % is necessary for a reliable start. The composition of biogas under normal, optimum fermentation conditions is usually above this value. However, the biogas production and its methane content underlies fluctuations. This can lead to varying starting conditions. Usually, the carburettor of CHP units is set to a fixed methane content. If the actual methane content differs from this value the start of the engine fails. As a result, a stable fermentation process is necessary for a reliable starting of the engine.

In order to handle changing methane conditions it is possible to use controllable carburettors in combination with a measurement of the gas composition (Liesner and Grewe 2013). So it is possible to adapt the settings of the carburettor to the actual gas composition.

3.2.2.5 *Part Load Operation of CHP Units*

Another option for the flexible production of electricity is the part load operation of CHP units. The advantage compared to the intermittent operation at nominal load is that the flexibility can be reached without additional start processes. In general, biogas CHP units can be operated at down to 40 % of their nominal load (ASUE 2011).

The engine is not running in its optimum conditions, which finally leads to additional stress. Auxiliary drive systems, the cooling circuit and the lubricant circuit are designed for the nominal load. With the part load operation, pumps and turbochargers no longer work at their optimum operating point. This causes increased lubricant consumption and auxiliary energy demand.

As the reduced exhaust gas volume flow is cooled faster as compared to the base load-operation, the part load operation is associated with a larger amount of condensate.

Also the combustion of the fuel/air mixture is no longer in the optimum range. The engine is exposed to higher stress due to unburnt components of the gas mixture (Jung and Müller 2008).

To avoid too high mechanical stress, manufacturers recommend minimum part loads of 40 to 50 % of the nominal load.

In summary, part load-operation leads to an increased engine stress and to a lower efficiency in the biogas utilisation.

Figure 3.12 shows the efficiency curve of an exemplary CHP unit in part load-operation. A significant loss of efficiency already takes place at part loads of less than 85 %. In practice, even higher efficiency losses are assumed, which can vary between 1 and 2 percentage points (Jung and Müller 2008).

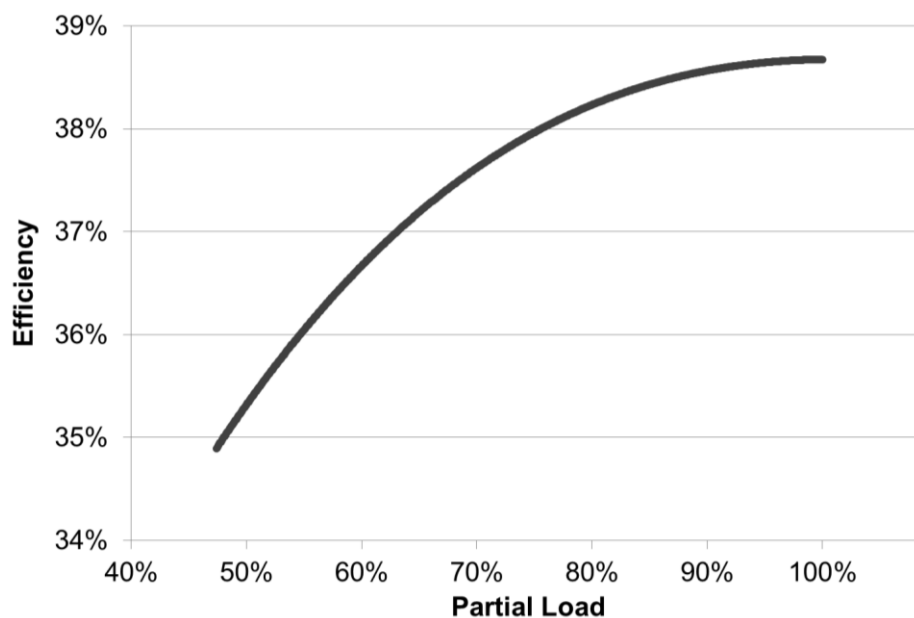


Figure 3.12: Efficiency Characteristic Curve of a CHP unit (2G Energietechnik 2011)

Intermittent operation at nominal load is more energy efficient than continuous operation at part load below approximately 90% (Jung and Müller 2008).

High part load operating times increase the risk of losing additional electricity market revenues due to the inefficient utilisation of the biogas, hence higher demand for substrate.

It can be assumed that the CHP unit in part load operation is less stressed than in an intermittent operation. But an intermittent operation of the CHP unit needs a shorter operating time to produce the same amount of electricity as in part load operation. For this reason, a longer service life of the CHP unit in intermittent operation can be expected.

Nevertheless, situations can arise in which the part load operation seems quite interesting for biogas plants. These situations can be for example starting problems due to short-term biological problems. Especially the heat supply of the biogas plant or external customers can be an important argument for the part load operation.

3.3 Incentives for Controllable Electricity Production

For a useful contribution of controllable electricity production within an electricity system with a high amount of fluctuating and supply-dependent power output, it is necessary to use management instruments which enable an utilisation of the available quantity of gas as well as economic management instruments for a controllable electricity production.

The trading of electricity provides appropriate incentives for a generation management. A distinction between energy-only markets and the market for balancing power is made.

Among the energy-only markets the electricity volumes are traded at the stock exchange or off-market at the over-the-counter-market (OTC-market).

Within the electricity exchanges for Germany, long-term products are traded at the futures market of the *EEX Power Derivates GmbH*, Leipzig, and short-term products are traded at the spot-markets of the *EPEX Spot SE*, Paris.

In addition, a legal funding of the controllable electricity production via Biogas was introduced in Germany, which is described below.

3.3.1 Spot-Market of the *EPEX Spot SE*

The spot-markets of the *EPEX Spot SE* offer the possibility to control the generation management.

Among the spot-markets of the *EPEX Spot SE* a distinction is made between the day-ahead auction and the intraday market.

At the day-ahead auction, the electricity supply of each hour of the following day is traded until 12 p.m.. For the pricing, the marginal costs curve of the electricity production, the merit order, is used. This price is valid for the entire market area.

High and low residual loads, which are influenced by the fluctuating electricity production from wind and photovoltaic are affecting the electricity price. High residual loads result in high electricity prices. If the controllable electricity production via biogas follows this price signal, it is ensured that the controllable electricity production via biogas takes place when there are high residual loads in the market area to cover, respectively the share of fluctuating electricity production via biogas at the market is low.

For illustration, [Figure 3.13](#) shows the influence of the residual load on the electricity prices. Therefore, the supplied power from conventional and renewable electricity production, the

current electricity consumption and the electricity prices on the spot-market of the EPEX Spot SE on 25 April 2013 are shown. With the decline in residual load by the high share of renewable generated electricity between 8 p.m. and 5 a.m., also the electricity prices decline within this period. On this exemplary day, the highest residual loads are between 6 and 11 a.m. and between 7 and 11 p.m. These are congruent with the electricity price peaks. An appropriate, on these price development adapted controllable electricity production, enables higher revenues through the sale of electricity compared to a base load operation.

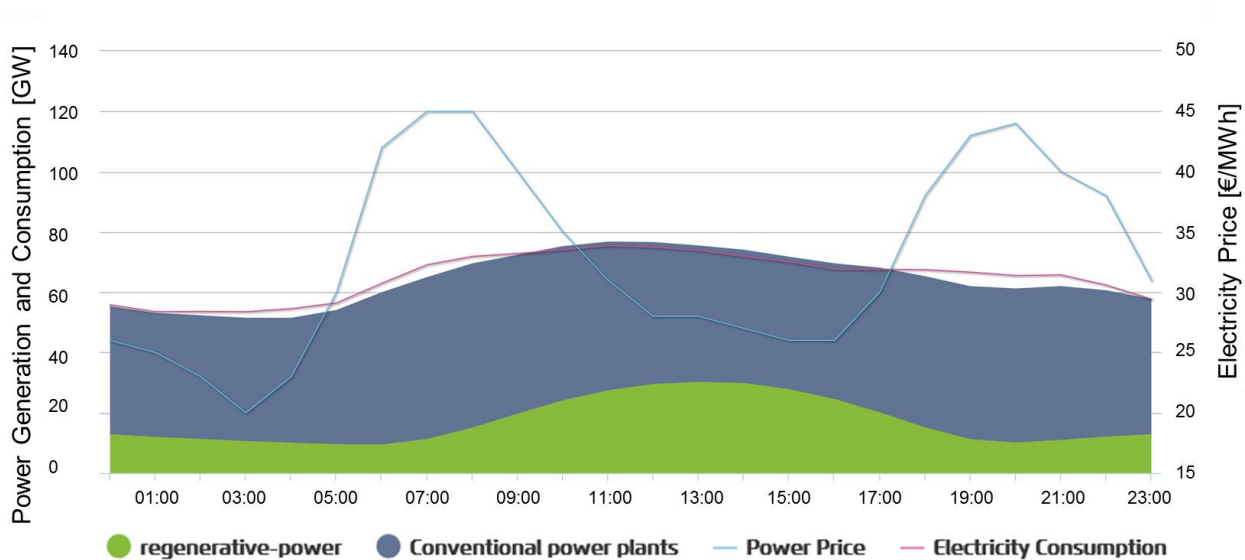


Figure 3.13: Electricity Price, Power Generation and Consumption on April 25, 2013 (Agora Energiewende 2015)

The influence of the renewable electricity production on the prices of the EPEX Spot SE day-ahead auction can also be shown in the development of the average electricity prices of each single hour within the last years (Figure 3.14). It can be clearly seen that the level of the electricity prices decrease from year to year. The average electricity price in 2011 was 51.1 €/MWh. In 2014, the average electricity price of the day-ahead auction has dropped to 33.6 €/MWh. This is due to the expansion of renewable energies with the associated increase in the share of electricity from renewable energy sources in the gross electricity consumption of 20.4 % in 2011 to 25.5 % in 2013 (BMWi 2015). In 2017 the average electricity price of the day-ahead auction was 33,1 €/MWh. The course of the electricity prices is similarly volatile as in previous years.

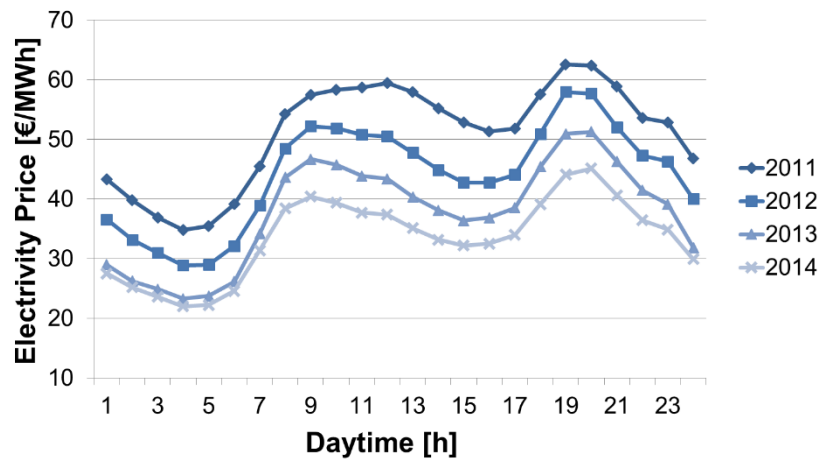


Figure 3.14: Development of Average Electricity Prices at the EPEX Spot SE Day-Ahead Auction

On the intraday market of the EPEX Spot SE 15-minute electricity contracts are traded. The trade of each 15-minute contract takes place from 3 a.m. of the previous day to 45 minutes before delivery. The 15-minute contracts allow to respond to deviations regarding the consumption and production forecasts.

As shown in [Figure 3.15](#), the average electricity prices at the day-ahead auction and the intraday market are almost congruent.

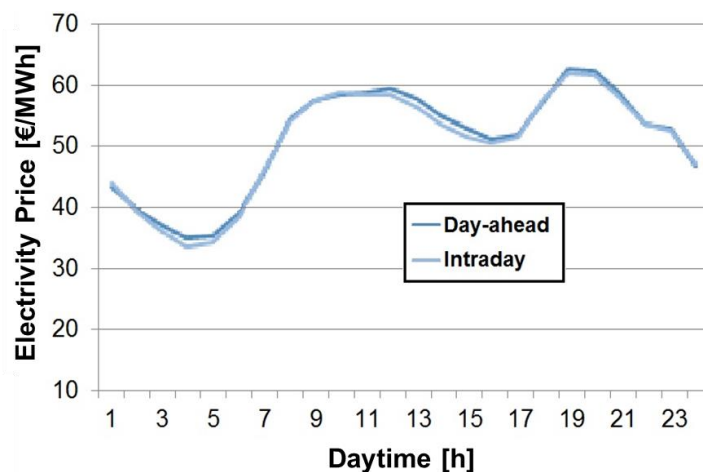


Figure 3.15: Comparison of Average Electricity Prices of the Day-Ahead Auction and the Intraday Market 2011

An examination of the two markets in terms of the minimum and maximum electricity price values (Figure 3.16 and Figure 3.17) shows that the day-ahead-market is distinctly less volatile than the intraday market.

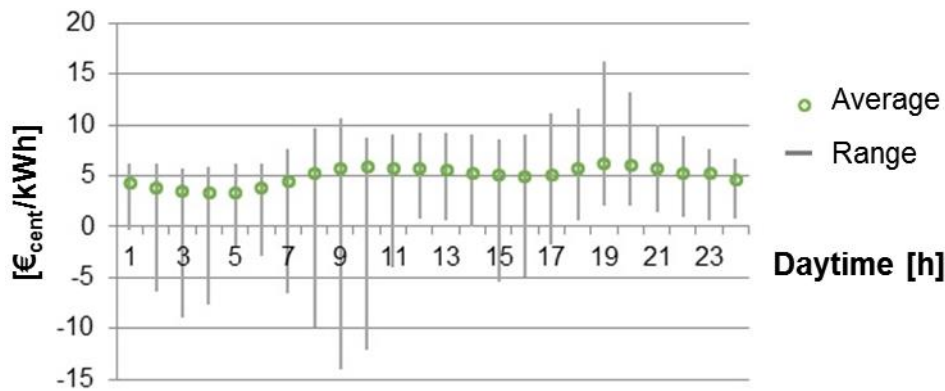


Figure 3.16: Candlestick Chart of the Average Electricity Prices at the Intraday Market 2011

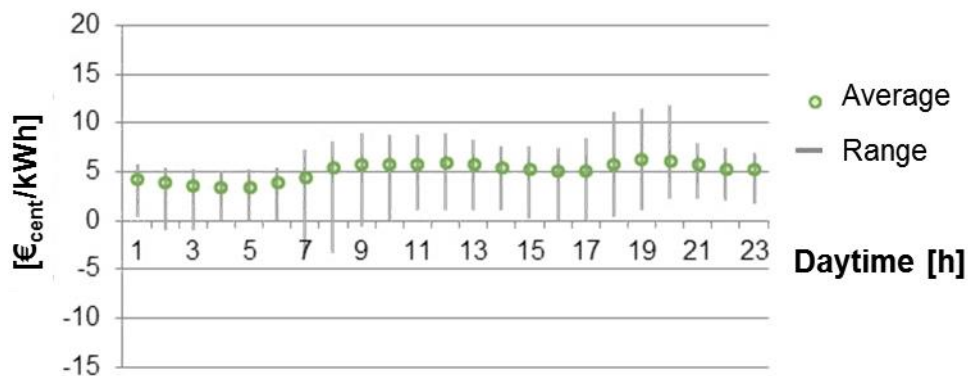


Figure 3.17: Candlestick Chart of the Average Electricity Prices at the Day-Ahead Auction 2011

Both spot-markets of the EPEX Spot Se are suitable for the aimed generation management and comparable electricity prices are achieved. Since the electricity prices at the Day-Ahead Auction are determined the day before, the Day-Ahead Auction is recommended as control instrument for the controllable electricity production via biogas plants. With the Day-Ahead Auction, future price developments can be better and more predictable integrated in the electricity production schedule.

3.3.2 Balancing Power

The provision of balancing power serves to guarantee the balance between electricity production and consumption in case of deviations in the supply and purchasing behavior based on forecasts of deliveries and purchase of the energy-only markets. The balancing power is tendered out collectively by the German transmission system operators via the internet platform regelleistung.net. Aim of the balancing power is to keep the nominal frequency of the grid at 50 Hz. A distinction is made between positive and negative balancing power. Positive balancing power means that the power of the electricity production is increased. Negative balancing power means a reduction of the power of the electricity production.

Further, distinctions are made between three types of balancing power (Amprion n.d.):

- **Primary Balancing Power:** Is obtained automatically from the transmission operator from controllable power plants. Availability within 30 seconds. Participating power plants are keeping reserve production capacities free.
- **Secondary Balancing Power:** Is obtained automatically from the transmission operator from controllable power plants. Availability within 5 minutes. Is initiated by the transmission area operator, in which the increased consumption/production was originated.
- **Minute Reserve** Requested by the transmission system operator from each supplier. Used for longer pending use of secondary control power in particular by power plant outages, usually as schedule supply on the full quarter of an hour. An activation and deactivation within 15 minutes must be possible.

In accordance with § 22 para. 2 Energiewirtschaftsgesetz (EnWG), the German transmission grid operators have to carry out a tendering procedure for the provision of balancing power. For the participation at this procedure the participants must be pre-qualified. The requirements for the pre-qualification of participation in the balancing power market are defined in annex D of the transmission code 2007 (VDN 2007a)

Since biogas plant operators have the possibility to gain an additional revenue with the supply of balancing power, the main tasks of the biogas operation for the prequalification

are described below. Which requirements have to be met depends on the type of balancing power.

For the prequalification to participate in the **primary balancing power** it must be ensured that the offered control range per technical unit is not less than ± 2 MW (VDN 2003). The offered primary balancing power must be available throughout the entire offer period.

Secondary balancing power is tendered for the duration of one week in individual time slices of each hour. A distinction is made between major and minor time and between negative and positive balancing power. Minor time is between 00:00 to 08:00 am. and between 08:00 to 12:00 pm.. On Saturdays, Sundays and national holidays the whole day is minor time (regelleistung.net n.d.). The minimum offer for is 5 MW_{el} (regelleistung.net n.d.). In contrast to the primary balancing power, this value refers to the total tendered power. So the pooling of capacities is possible, thereby the participation of biogas plants at secondary balancing power is possible. The prequalified control power has to be activated or deactivated within 5 minutes. The maximum time to be covered is 15 minutes per call. Regarding the reliability, there has to be a proved time availability of the offered power of at least 95 % for the duration of the tendering period (FNN 2009).

As set in the transmission code (VDN 2007b), the call of secondary balancing power takes place automated in accordance to the IEC standard 870-5-101. The regulations for the pooling of several plants are set in FNN 2009.

In comparison to the secondary balancing power, the tendering of **minute reserve** is carried out daily over periods of 4 hours. The minimum set power is 5 MW. Also at the minute reserve, the pooling of several plants is possible. The operation availability must be 100 %. If the operation availability is less than 100 %, it is possible to prequalify separate plants within a pool (VDN 2007b).

Therefore, for the participation at the balancing power market only the markets of secondary balancing power and minute reserve are worth considering.

In both markets the providing readiness of power is remunerated via a power price. If balancing power will be actually required, the electrical work is remunerated via a working price.

It has to be stated, that the providing of balancing power is a system service for the electricity grid. The service is provided unplanned and in short term. Thus, by participating in

the balancing power market no balance of the residual load, which corresponds with the demand of controllable electricity production, as described in chapter 2.2.1 takes place.

3.3.3 Policy Incentive Funding

Within the EEG 2012 and the introduction of the market bonus scheme and the flexible premium, instruments were created by the legislator to incentivise the controllable electricity production via Biogas plants.

3.3.3.1 Market Bonus Scheme

The introduction of the market bonus scheme enables biogas plants to obtain higher remunerations in comparison to the ordinary remuneration for the electricity production via biomass according to § 27 EEG 2012. The related regulations are set in §§ 33a till 33i EEG 2012. In the EEG amendment of 2014, this regulations are continued in general with §§ 34 till 36 EEG 2014.

Core of the market bonus scheme is the optional market bonus. If a plant changes to the market bonus scheme, the plant renounces the ordinary EEG remuneration. The produced electricity can be sold directly to third parties or on the stock exchange. The optional market bonus is intended to cover the price difference between the market value of the produced electricity and the regular EEG remuneration. It is calculated according to (3):

$$\text{Market Bonus} = \text{Application Value} - \text{Reference Value} \quad (3)$$

The assumed application value in (3) corresponds to the theoretically entitled regular remuneration plus a value of 0.2 ct/kWh (since 01/01/2015). The reference value corresponds to the actual monthly average value of the hourly contracts on the spot market of the EPEX Spot.

The market premium can be claimed if:

- no avoided grid utilisation is claimed,
- the plant can be remotely controlled § 6 EEG 2012 and § 36 EEG 2012 and
- the electricity is balanced in a balancing or sub-balancing group, in which only electricity from renewable sources according is traded.

Figure 3.18 illustrates the remuneration structure for the market bonus scheme compared to a regular EEG remuneration. Since for the claiming of the market bonus a flexible operation of the electricity production is not necessary, a higher remuneration in comparison to

the theoretically entitled regular remuneration is already possible in baseload operation. Through a market-adapted operating mode of the electricity production revenues beyond the monthly average value of the spot market of the EPEX Spot are possible.

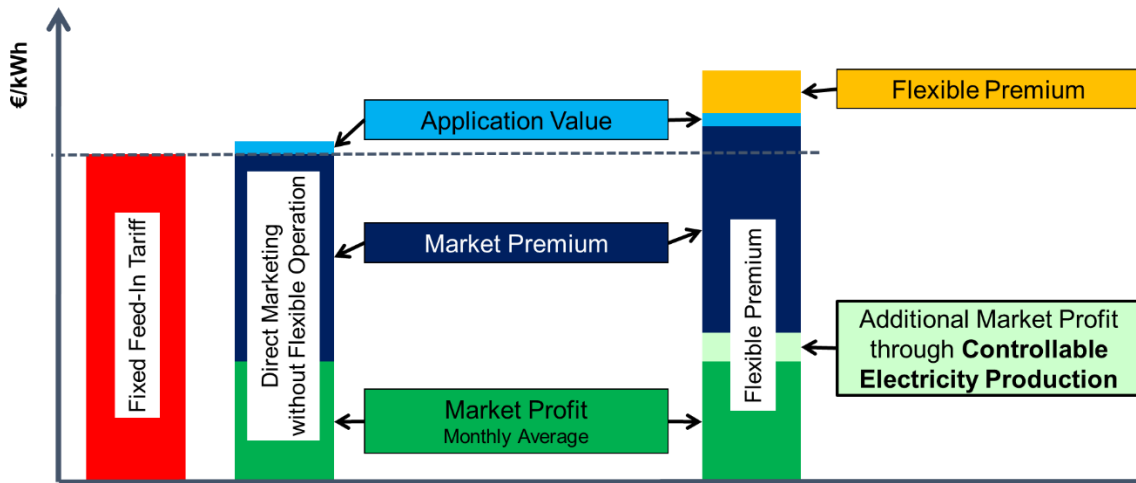


Figure 3.18: Electricity Remuneration with the Market Bonus Scheme

To get access to the markets, the produced electricity has to be traded via an electricity trader. Usually, the electricity producers are paid pro rata on the additional earnings. Additional earnings in comparison to the monthly average value of the spot market of the EPEX Spot SE can be achieved by market optimised electricity production schedules or through a clever trading of the produced electricity at different markets by the trader, for example the participation at the balancing power markets.

3.3.3.2 Flexible Premium

Since the controllable electricity production via biogas is coupled with investments in additional electricity production- and if necessary additional heat- and gas storage capacities, the electricity generation costs connected with the flexible and controllable electricity production are more expensive than a regular base load operation. Under the EEG 2012 and § 33i with the flexible premium (FP) a capacity component, which rewards the provision of higher electricity production capacities as necessary for a base load operation, was introduced in order to enable an economic realisation of a flexible electricity production. The flexible premium can be used in addition to the market premium. The entitlement to the premium consists for a period of ten years after the first application. Therefore, the technical suitability of the plant for the demand oriented electricity production has to be certified within a report of an accredited environmental verifier. In the course of the certification a three-day trial operation of the demand oriented operation has to be performed.

A demand oriented operation of the electricity production takes place if agreements or targets from the electricity producer and electricity trader are respected. An example of this is if the economic target of the plant operator and the electricity trader is to surpass the average spot prices (Grantner n.d.).

The amount of the capacity component (CC) is 130 € per kW flexibly provisioned additional installed capacity ($P_{\text{additional}}$) and year.

$P_{\text{additional}}$ is calculated by the difference between the installed electrical power (P_{inst}) and the rated power (P_{rated}). The rated power of the biogas plant is calculated by the quotient of the sum of the kilowatt hours generated in the respective calendar year and the sum of the complete time hours of the respective calendar year. In addition, a correction factor f_{cor} was introduced for the calculation of $P_{\text{additional}}$, which compensates the typical utilisation rate of biogas plants. For biogas plants with on-site electricity production f_{cor} is 1.1.

Thus, $P_{\text{additional}}$ is calculated following (4):

$$P_{\text{additional}} = P_{\text{inst}} - (f_{\text{cor}} \times P_{\text{rated}}) \quad (4)$$

The aim of the flexible premium is to create an actual flexibility of the electricity production. For this purpose, $P_{\text{additional}}$ is set deviated as follows:

- $P_{\text{additional}} = 0$, if $P_{\text{rated}} \leq 0,2 \cdot P_{\text{inst}}$
- $P_{\text{additional}} = 0,5 \cdot P_{\text{inst}}$, if $P_{\text{additional}}$ (according to (4)) $\geq 0,5 \cdot P_{\text{inst}}$

The amount of the flexible premium is calculated according to (5):

$$FP = \frac{P_{additional} \times CC \times 100 \frac{Cent}{Euro}}{P_{rated} \times 8760 h} \quad (5)$$

3.3.4 Chapter Summary

The analysis of the incentives for a controllable electricity production shows, that with the Spot markets of the EPEX Spot SE, existing markets are available, which are providing financial incentives to meet the aspirations for the demand driven controllable electricity production (see chapter 2.2.1). Especially the day-ahead market enables a predictable operation of the controllable electricity production adapted to a prognosticated residual load. For this reason, the calculated additional revenue within the concept development refers to the day-ahead markets of the EPEX Spot SE.

4 Concept Development

Basis of the concept development is an economic, and in the sense of the power grid meaningful use of the existing flexibilities of a biogas plant. In this context plant concepts with different flexibilities, defined by the ratio of the installed electricity production capacities to the rated power and the gas storage volume, are defined. The assessment of the economy is done by using different electricity market optimised schedules for the electricity production

4.1 Parameter Study

The concept development as well as the assessment of the economy is based on a parameter study. Thereby, different rated powers of biogas plants are considered and the ratio of the installed electricity production capacity to the rated power, the gas storage capacities and electricity production strategies are varied.

In order to consider a representative cross section of typical rated powers of agricultural biogas plants following rated powers are taken into account:

- $P_{\text{rated}} = 250 \text{ kW}_{\text{el}}$
- $P_{\text{rated}} = 550 \text{ kW}_{\text{el}}$
- $P_{\text{rated}} = 750 \text{ kW}_{\text{el}}$
- $P_{\text{rated}} = 1,000 \text{ kW}_{\text{el}}$

The ratio of the installed electricity production capacities to the rated power are varied as shown in [Table 4.1](#). To restrict the huge potential for different configurations, the concepts are based on existing biogas plants. That means in relation to [Figure 3.3](#) that before the modification of the biogas plants one CHP unit (CHP1) with the capacity of the rated power was already installed. The capacity of the second new additional installed CHP unit (CHP2) corresponds to the necessary capacity, which is needed to reach the required total installed capacity.

Table 4.1: Considered Electricity Production Capacities

Rated Power [kW _{el}]	P_{inst}/P_{rated}	Installed Capacity [kW _{el}]	CHP1 [kW _{el}]	CHP2 [kW _{el}]
250	1.25	312.5	250	112.5
	1.5	375		175
	2	500		250
	3	750		500
550	1.25	687.5	550	137.5
	1.5	825		275
	2	1,100		550
	3	1,650		1,100
750	1.25	937,5	750	187,5
	1.5	1,125		375
	2	1,500		750
	3	2,250		1,500
1,000	1.25	1,250	1,000	250
	1.5	1,500		500
	2	2,000		1,000
	3	3,000		2,000

To investigate the influence of the consideration of current electricity prices and flexibility of different control strategies on the economy of each design, different schedules are considered:

1. Schedule optimised regarding the prices of EPEX Day-ahead – “average day”
→ one schedule adapted on the prices of each hour of an average day for a whole year
2. Schedule optimised regarding the prices of EPEX Day-ahead – “average week”
→ one schedule adapted on the prices of each hour of an average week for a whole year
3. Schedule optimised regarding current prices of the EPEX Day-ahead “year”
→ Daily varying schedule over one year

The gas storage volume of each concept depends on the rated power and varies between the 6, 12 and 24 times of the amount of biogas which is produced within one hour.

To distinguish the large number of variants, following nomenclature is used:

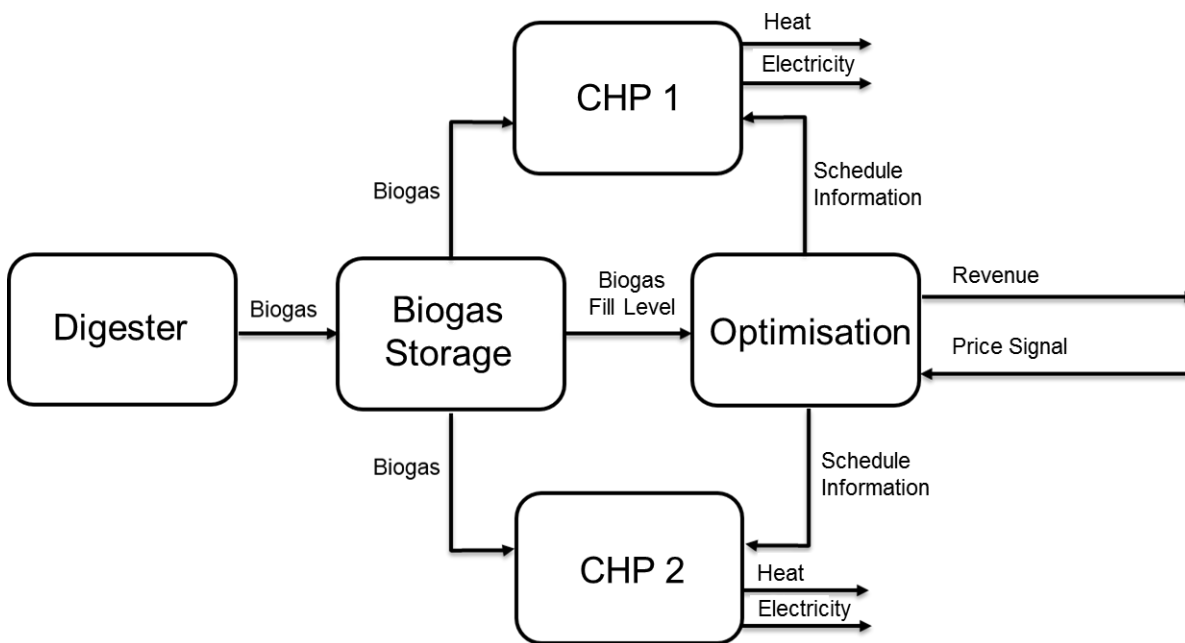
- $P_{\text{inst}}/P_{\text{rated}}$ - Schedule Number – Gas Storage Capacity

For example: “1.25-1-6” means

- $P_{\text{inst}}/P_{\text{rated}} = 1.25$
- Optimised schedule 1 – average day
- Gas storage capacity: 6 h

4.2 Control Strategies

In order to create control strategies which enables a meaningful use of the flexibilities of biogas plants in an economic and technical way, the *Institute of new Energy Systems of the Technische Hochschule Ingolstadt* developed different optimised electricity production schedules (Bär 2016). Bär 2016 used an optimisation tool, based on a mixed integer linear algorithm. This optimisation tool is capable to generate electricity production schedules, which are optimised on a time-dependent price signal. As input value a time-dependent biogas production is used. The optimization is subjected to the restriction of the gas storage and the electricity production capacity. These correlations are summarised in [Figure 4.1](#). As further restriction, it is determined that the electricity production shall only take place with full load.



[Figure 4.1](#): Information Flow of the Optimisation Tool (Bär 2016)

As shown in Formula 6 and 7, the aim of the objective function of the optimisation is to maximise the revenue generated by the electricity sales.

$$\max \sum_{n=1}^N \sum_{t=1}^T r_{CHP,n,t} \quad (6)$$

with: $r_{CHP,n,t}$ = revenue at time step t [€]
 n = number of the CHP
 N = total number of the CHPs
 t = time step
 T = total number of time steps

$$r_{CHP,el,n,t} = P_{CHP,el,n,t}^{gen} \times e_{EPEX,t} \quad (7)$$

with: $r_{CHP,n,t}$ = revenue at time step t [€]
 $P_{CHP,el,n,t}^{gen}$ = electrical power of CHP n at time step t [kW_{el}]
 $e_{EPEX,t}$ = electricity price of EPEX Day-Ahead Auction at time step t [€/kW_{el}]

As price signal, the electricity prices on the EPEX Day-ahead auction of the German market area are used. In the following, the developed schedules refer to the electricity prices of the year 2014.

The varying parameters, described in chapter 4.1 are influencing the developed schedules in different ways. Depending on the price signal it is not possible or necessary to exploit the full flexibility of the biogas plant. These correlations are described in the following.

As example for the “average day” price signal [Figure 4.2](#) shows the optimised schedule for the variant 2-1-12 for a rated power of 550 kW_{el}. As can be seen by the contemplation of the gas storage fill level, only 60 % of the entire gas storage has to be exploited for the optimised schedule.

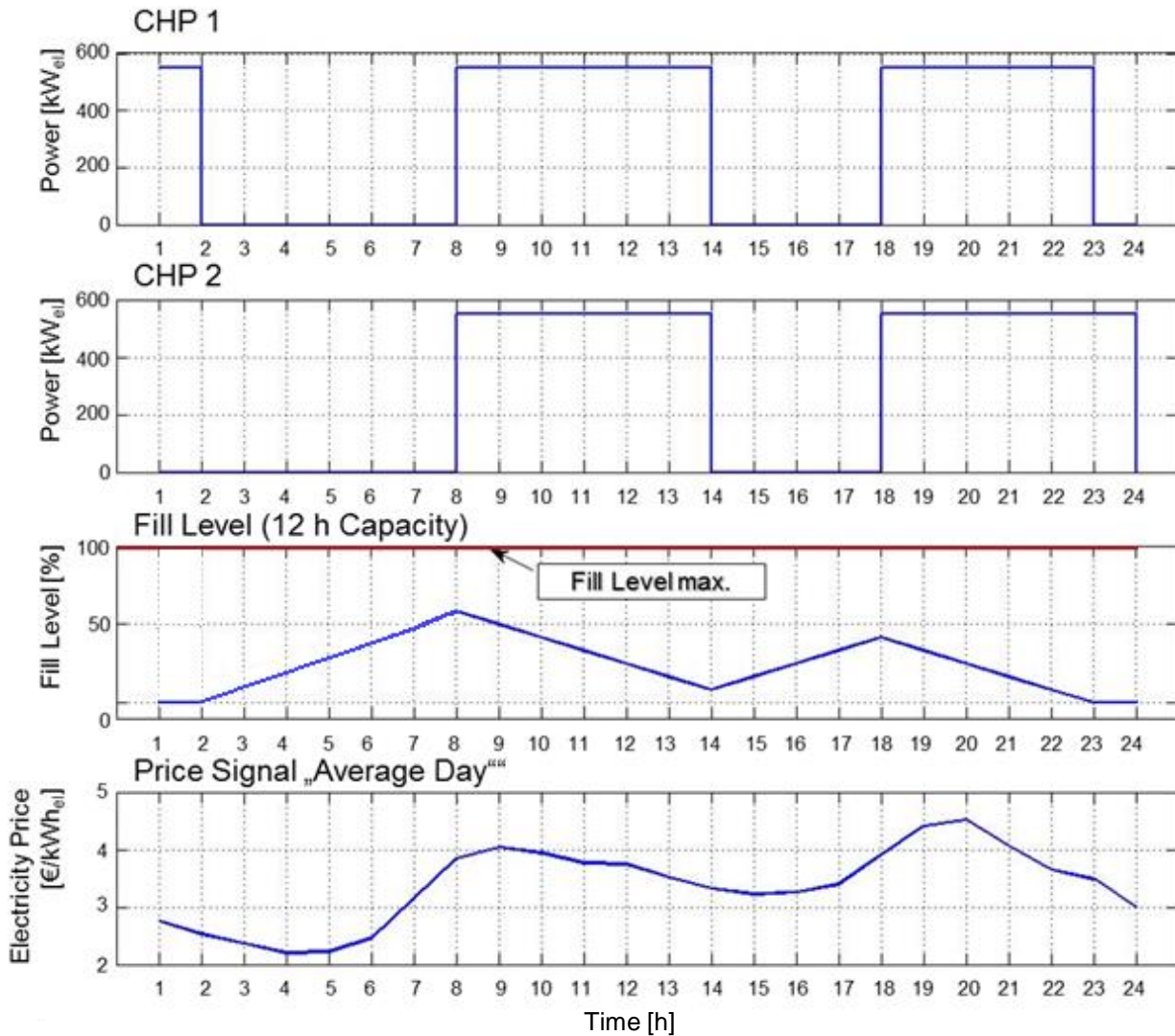


Figure 4.2: Electricity Production Schedules and Gas Storage Fill Level (12 h Capacity) for “Average Day”

If the schedule „average day“ runs 365 days a year, the specific additional revenues on the electricity market displayed in Figure 4.3 are reached. The specific additional revenues per year are stated specifically per kW of rated power (€/kW_{rated a}). This enables a transfer of the results to different plant sizes.

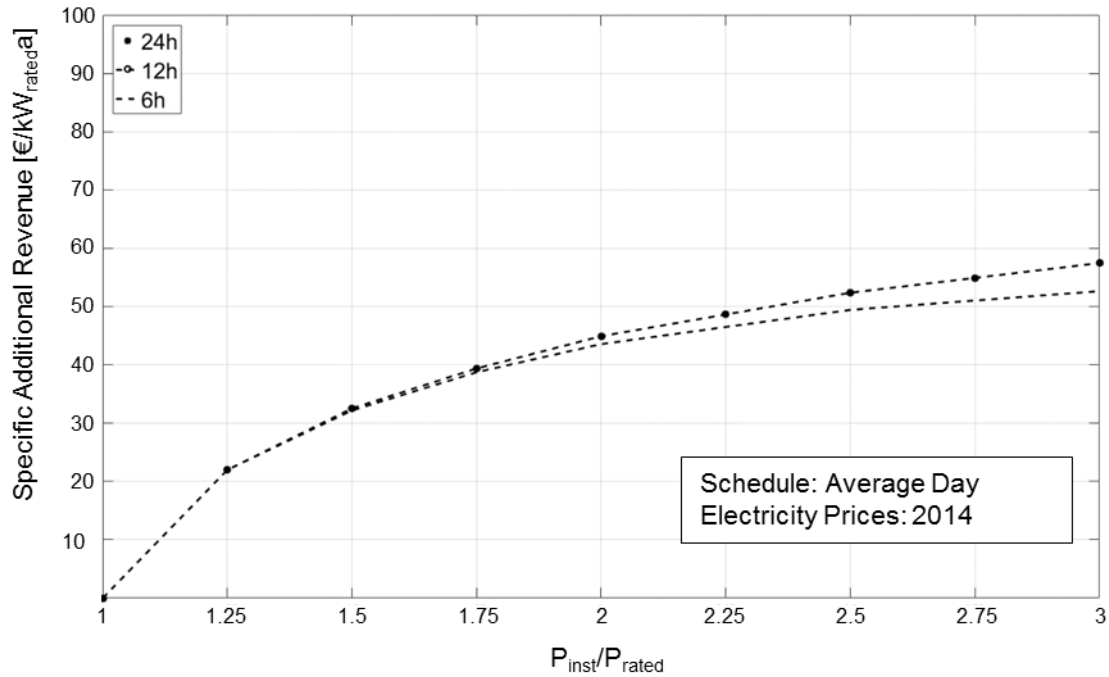


Figure 4.3: Specific Additional Revenues per Year for Schedule “Average Day”

An increase in the specific additional revenue is achieved already at a $P_{\text{inst}}/P_{\text{rated}}$ ratio of 1.25. Up to the ratio of 1.5 there is only a small influence of the gas storage capacity at the additional revenues. A noticeable increase of the influence of the gas storage capacity on the additional revenues can be stated from the ratio of $P_{\text{inst}}/P_{\text{rated}}$ 1.75 on. The maximum specific revenues in this consideration of the schedules for “average day” is achieved with 57.46 €/kW_{rateda} at a gas storage size of 24 hours and a ratio of $P_{\text{inst}}/P_{\text{rated}}$ of 3.

Since a gas storage capacity of 8 h is sufficient to reach the optimum “average day” schedule, it is irrelevant for the scheduling whether a gas storage capacity of 12 h, or 24 h is available. Higher revenues are not possible with an installation of larger gas storage capacities.

Figure 4.4 displays a schedule for variant 2-2-12 and Figure 4.5 one for variant 2-2-24. Both schedules are for a rated power of 550 kW_{el}. Within these examples, the schedule is optimised regarding the “average week” price signal. As can be seen, the prices on the EPEX Spot SE day-ahead auction are on the working days (hour 1 to hour 120) higher as on the weekends (hour 121 to 168). For this reason, it is meaningful for the schedules optimised regarding the “average week”, that on working days more biogas is converted into electricity as on the weekend and during the weekend the installed gas storage capacities have to be used. The influence of the gas storage capacity on the schedules can be

seen by a comparison of the gas storage fill levels in [Figure 4.4](#) and [Figure 4.5](#). At a gas storage capacity of 24 h, it is possible to shift the electricity production for longer periods to use the higher electricity prices on Monday and Tuesday (hours 1 to 48).

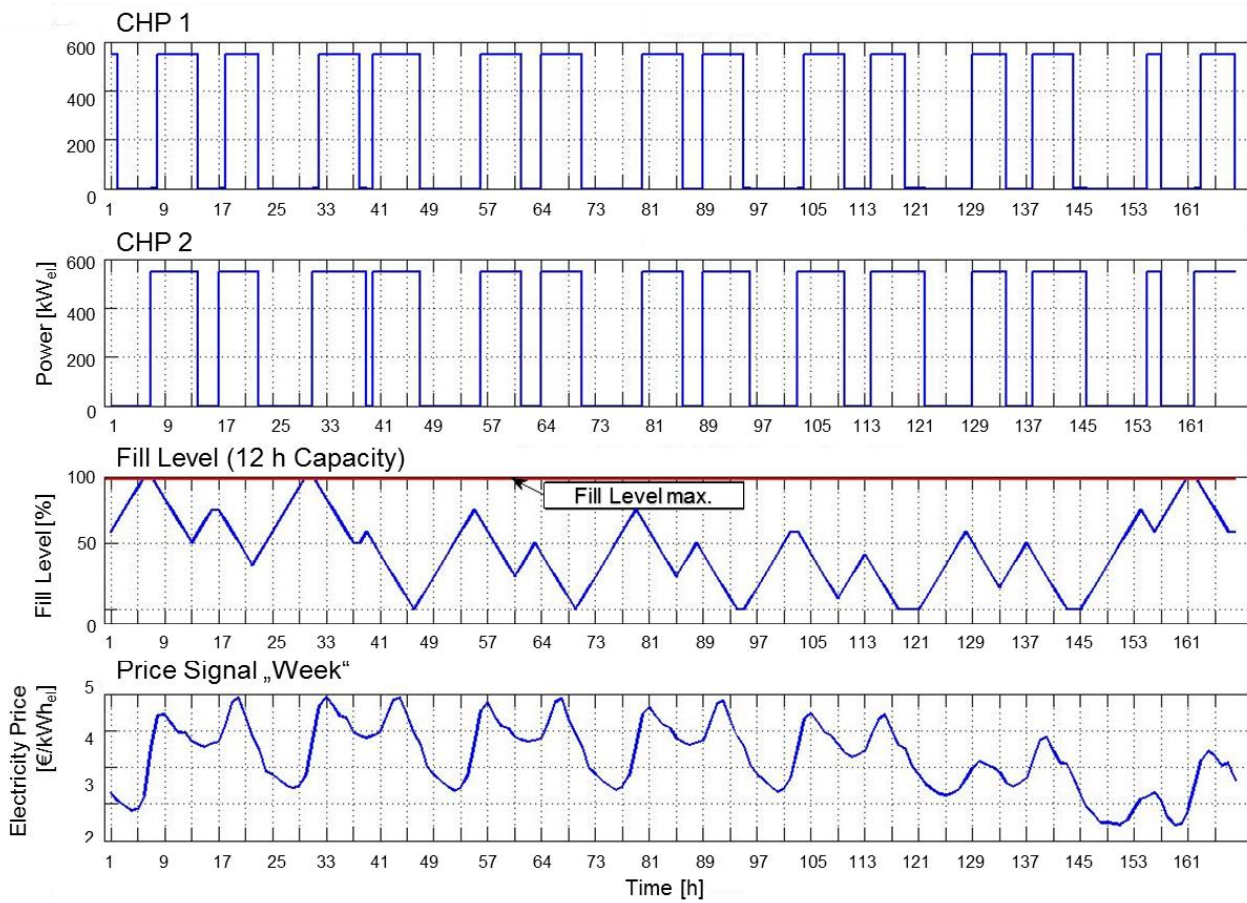


Figure 4.4: Electricity Production Schedules and Gas Storage Fill Level (12 h Capacity) for "Average Week"

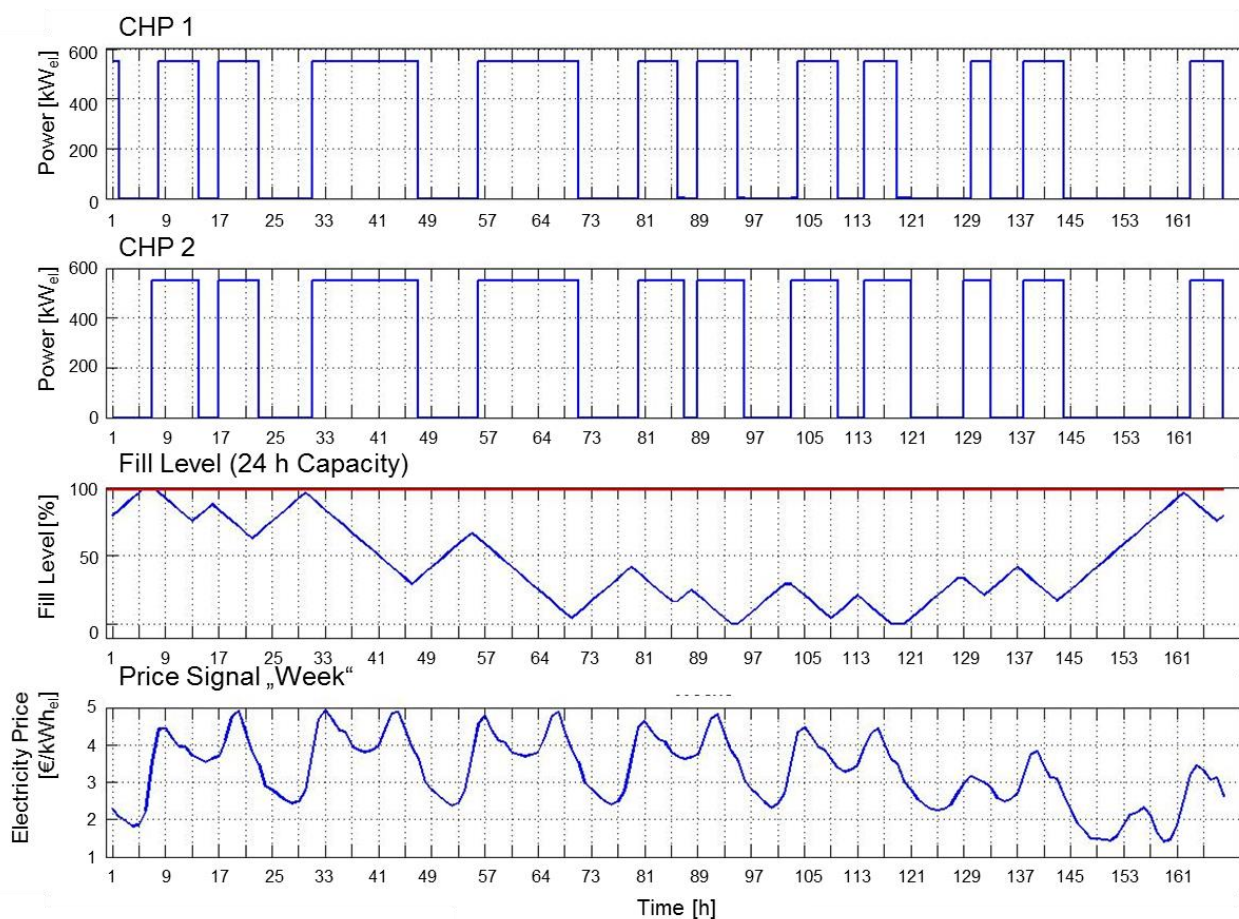


Figure 4.5: Electricity Production Schedules and Gas Storage Fill Level (24 h Capacity) for “Average Week”

The influence of the gas storage size on the reachable additional revenue is also reflected in the visualisation of the specific additional revenues (see [Figure 4.6](#)). Already at a $P_{\text{inst}}/P_{\text{rated}}$ ratio of 1.25 a noticeable difference regarding the revenues with different gas storage sizes can be considered. At a $P_{\text{inst}}/P_{\text{rated}}$ ratio of 3 and a gas storage capacity of 6 h specific additional revenues of 56.85 €/kW_{rated}a can be achieved. With a gas storage capacity of 24 h specific additional revenues of 78,29 €/kW_{rated}a are achievable.

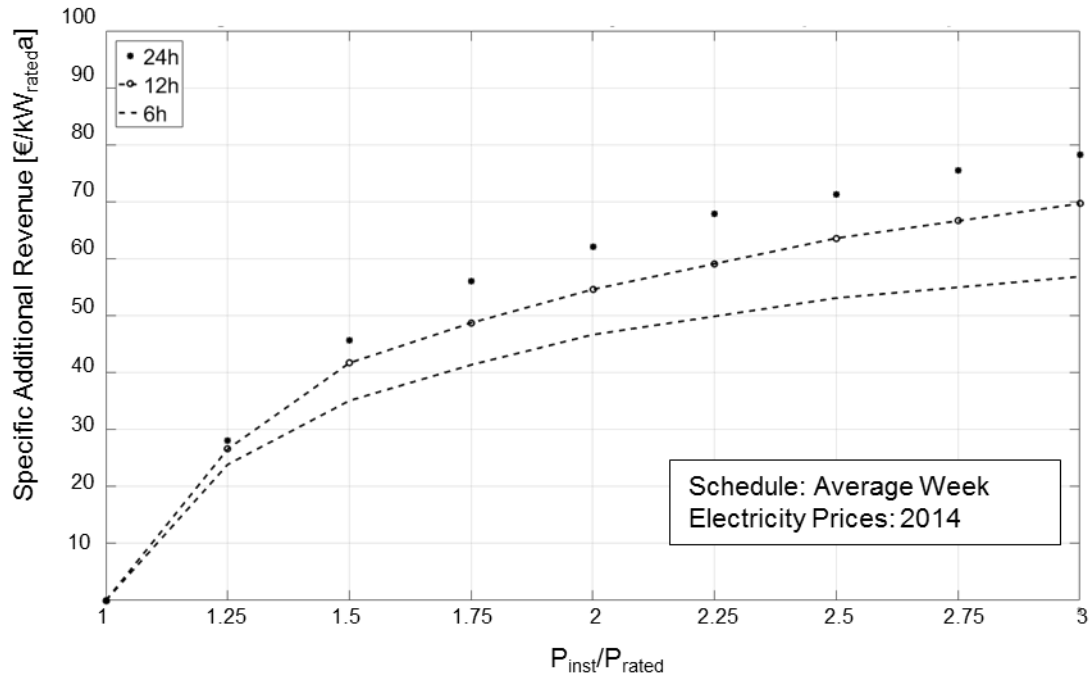


Figure 4.6: Specific Additional Revenues per Year for Schedule “Average Week”

Figure 4.7 illustrates the possible specific additional revenues for a daily optimised schedule (price signal “year”). With an increasing ratio of $P_{\text{inst}}/P_{\text{rated}}$ a clearly rising of the gas storage capacity can be reflected. At a $P_{\text{inst}}/P_{\text{rated}}$ ratio of 3 and a gas storage size of 6 h a specific additional revenue of 63.81 €/kW_{rateda} can be realised. With 92.80 €/kW_{rateda}, the highest specific additional revenue in this investigation are reached at a $P_{\text{inst}}/P_{\text{rated}}$ ratio of 3 and a gas storage capacity of 24 h.

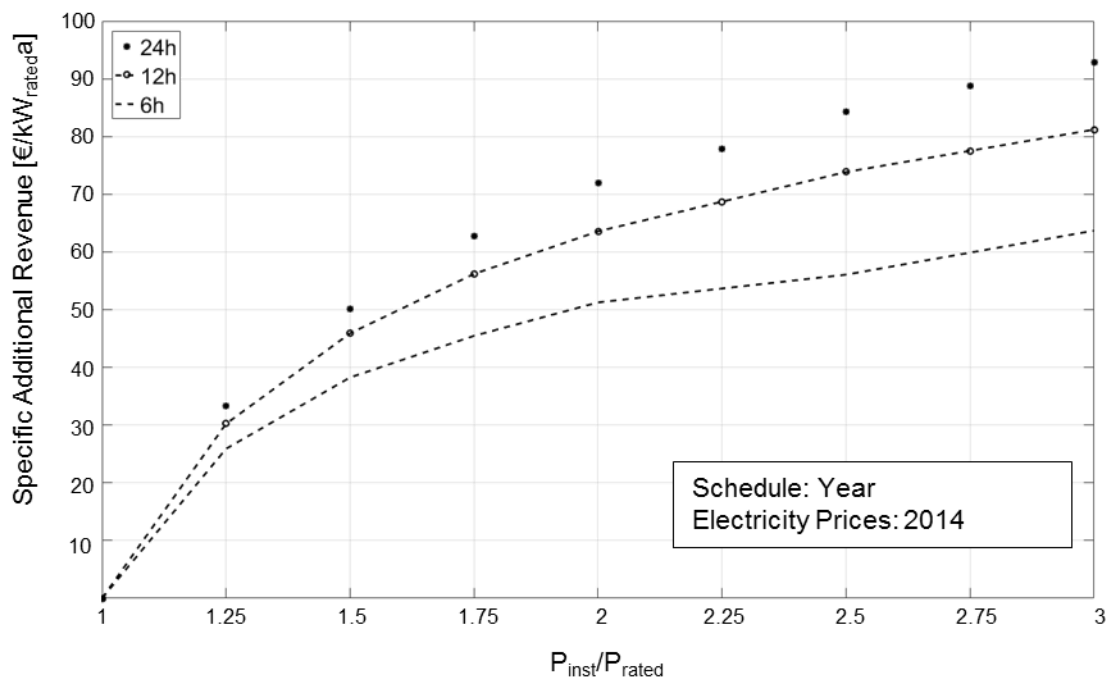


Figure 4.7: Specific Additional Revenues per Year for Schedule “Year”

The monetary most promising scheduling variant is based on a daily changing price signal. With such schedules it is possible to achieve higher revenues of up to 62 % in comparison to schedules based on the daily average. To fulfil such flexible schedules, it is a challenge for the plant operators and electricity traders.

4.3 Economic Analysis

In the following, the economics of biogas plants for controllable electricity production is investigated. The expected occurring additional cost and additional revenues are taken into account for a period of 10 years, the term of the flexible premium (see chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**).

4.3.1 Methodology

Regarding the accruing costs, the economic analyses are divided in four areas. Only the additional costs for the flexibilisation of the biogas plant are considered.

- Capital related costs
- Supply related costs
- Operational related costs
- Other costs

Capital Related Costs

Within the capital related costs, all additional investments are considered

- **Additional CHP** – Installed capacity (P_{inst}) minus rated Power (P_{rated}).
 - The costs are calculated according to ASUE 2014. Additionally, 60 % extra costs for the installation of the additional CHP and 2 % for the flexibilisation auxiliary equipment are estimated.
- **Additional Gas Storage** – An existing gas storage for a period of 6 h of the produced biogas quantity is assumed. Gas storages capacities beyond 6 h are included in the capital related costs.
 - The costs for air supported double layer systems are calculated according to quotations of the German market leader Sattler Ceno TOP-TEX GmbH. In addition, an extra surcharge for the installation of additional supporting air blowers is added.
- **Fill Level Monitoring** – A water gauging system inclusive control and installation
 - The costs are fixed at a general charge of 10,000 € according to quotations of the manufacturer Seitz Electric GmbH.
- **Gas Conditioning / Gas Pipe System** – Gas line and gas treatment (activated carbon filter / dehumidification) adapted to the capacity of the additional CHP.

- 85 €/kW_{el} of the capacity of the additional CHP are estimated (Keymer 2013).
- **Control System** – Adaptions for the flexibilisation with regard to the control system.
 - According to quotations of the control manufacturer Burghart GmbH & CO KG, a general charge of 10,000 € is estimated.
- **Transformer / Grid** – Adjustments of the feed-in power of the transformer respectively the grid according to the capacity of the CHP.
 - 80 €/kW_{el} of the capacity of the additional CHP are estimated.

The annuity method is used to calculate the annual repayment amounts. In contrast to the repayment loan, the rate to be paid remains constant over the entire maturity of 10 years. This requires a constant interest rate for the loan, which is set at 2 %.

Supply Costs

The energy costs of the additionally installed consumers are listed in the supply costs. As electricity price reference, 21 ct/kWh_{el} are charged. The supply costs are broken down as follows.

- **Additional Parasitic Energy CHP** – Electricity consumption by auxiliary equipment and intermittent operation.
 - Each cycle leads to an electricity consumption of 10 kWh_{el}. 5 CHP cycles per day are assumed.
- **Parasitic Energy Gas Storage** – Based on offers for air supported double layer systems, the electrical output of the supporting air blowers depends on the rated power of the biogas plant.
 - A running time of the air blowers of 2,920 h/a through the flexibilisation is assumed.

The present value method (compounding) is used to calculate the annual supply costs. This determines the present value of future payments. Therefore, an inflation of 2 % is assumed.

Operational Related Costs

The operational related costs include items such as the servicing, maintenance and inspection of the additionally installed technical facilities.

- **CHP** - Maintenance costs through flexibilisation.
 - Additional to the maintenance costs according to ASUE 2014, 5 % extra costs per installed kW_{el} is estimated.
- **Gas storage** - Maintenance costs through flexibilisation.
 - 3 % of the investments for gas storage and fill level monitoring per year.
- **Gas Conditioning / Gas Pipe System** – Maintenance costs mainly for activated carbon filters.
 - 1 % of the investment costs for the gas pipe system / gas conditioning per year.
- **Control System** - Maintenance costs through flexibilisation.
 - 3 % of the investment costs for the control system per year.
- **Transformer / Grid** - Maintenance costs mainly for the transformer.
 - 1 % of the investment costs for transformer / grid per year.
- **Amount of Work** – Additional required work for the plant operator through flexibilisation.
 - An increase of 10 % of the normal working hours (6 h/d for a 500 kW_{el} bio-gas plant (KTBL 2009)) is assumed. The costs per working hour are 15 €/h.

To determine the present value of future payments, the present value method (compounding) is used to calculate the annual operational related costs. Therefore, an inflation of 2 % is assumed.

Other Costs

The other costs include one-off costs as well as annual recurring cost items. These are broken down as follows.

- **Planning** – Planning of conversion measures.
 - A total of 40,000 € is charged for the planning.
- **Official Permit**
 - A total of 8,000 € is charged for the necessary permits (Keymer 2013).
- **Reports** – Reports regarding the controllable electricity production (e.g. report of an accredited environmental verifier).
 - A total of 3,500 € is charged for the necessary reports.
- **Insurance**
 - 0.5 % of the capital related costs are charged for the necessary insurances per year.

For the calculation of the annual other costs, the present value method (compounding) is used for the annual recurring cost items and the annuity method is used to calculate the annual repayment amounts of the one-off costs.

Additional Revenues

To quantify the additional revenues by means of the controllable electricity production, the following items are taken into account.

- **Flexible Premium** – See chapter 3.3.3.2
- **Application Value** – See chapter 3.3.3.1
- **Additional Market Profits** – See chapter 4.2

Cost-Revenue Comparison

To evaluate the costs and revenues through the flexibilisation of the electricity production of biogas plants, the following key figures are determined.

- Annual profit, respectively loss
- Return on investment
- Additional electricity generation costs through flexibilisation

4 Concept Development

All these key figures are summarised in overview sheets (see Table 4.2). The overview sheets of every variant of the parameter study are in the appendix.

Table 4.2: Example of an Overview Sheet

Variant 2-1-6											
General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]	Gas Storage		General Conditions					
Rated Power [kWel]	550			Gas Storage [h] (6 h existing)	6	Electricity Purchasing Costs [€/kWel]	0.21				
Installed Capacity [kWel]	1,100			Additional Capacity [h]	0						
Padditional [kWel]	495			Additional Volume [m³]	0	Interest	0.02				
						Term [a]	10				
CHP 1 [kWel]	550			4,015	2,208,250	Inflation	0.02				
CHP 2 (additional CHP) [kWel]	550	4,745	2,609,750	Planning Costs [€]	40,000						
Total Electricity Production [kWhel/a]	4,818,000										
Additional Earnings Electricity Market [€/kWel; rated a]	43.56										
Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	490,114.47	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	46,750.00	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	44,000.00	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37
Investment Total without Interest	594,864.47										
Sum	662,241.96	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		467.50	476.85	486.39	496.11	506.04	516.16	526.48	537.01	547.75	558.71
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		440.00	448.80	457.78	466.93	476.27	485.80	495.51	505.42	515.53	525.84
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	80,129.97	7,317.99	7,464.35	7,613.64	7,765.91	7,921.23	8,079.65	8,241.25	8,406.07	8,574.19	8,745.68
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	36,256.82	3,311.21	3,377.43	3,444.98	3,513.88	3,584.16	3,655.84	3,728.96	3,803.54	3,879.61	3,957.20
Other Costs Total without Interest	87,256.82										
Sum	93,033.35	8,988.86	9,055.09	9,122.64	9,191.54	9,261.81	9,333.50	9,406.61	9,481.19	9,557.26	9,634.86
Costs	878,888.92	86,502.26	86,794.27	87,092.12	87,395.92	87,705.80	88,021.88	88,344.28	88,673.13	89,008.56	89,350.69
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	589,589.93	64,350.00	63,088.24	61,851.21	60,638.44	59,449.45	58,283.78	57,140.96	56,020.55	54,922.11	53,845.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	262,313.61	23,956.19	24,435.32	24,924.02	25,422.50	25,930.95	26,449.57	26,978.56	27,518.13	28,068.50	28,629.87
Sum	940,190.85	97,942.19	96,970.61	96,037.05	95,141.16	94,282.58	93,460.97	92,676.01	91,927.40	91,214.83	90,538.04
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		11,439.93	10,176.34	8,944.94	7,745.24	6,576.78	5,439.09	4,331.73	3,254.27	2,206.28	1,187.35
Return on Investment		2%	1%	1%	1%	1%	1%	1%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.019

4.3.2 Results

The cumulative profit / loss as well as the average return on investment and additional electricity generation costs through flexibilisation over 10 years for the different rated powers are shown in [Table 4.3](#) to [Table 4.6](#).

The return on the individual variants, shown in [Table 4.3](#) to [Table 4.6](#), is divided into three types:

- **Green**: Return > 2 %
- **Yellow**: Return 0 % - 2 %
- **Red**: Return < 0 %

Based on the parameter study, it can be seen that only the variants with high rated power (750 kW_{el} respectively 1,000 kW_{el}) achieve a return higher than 2 % over the 10-year running time. The highest returns are reached, if no additional investment for the gas storage are necessary and a schedule, flexible as possible, is used.

Table 4.3: Summary Economic Assessment – $P_{\text{rated}} = 250 \text{ kW}_{\text{el}}$

Gas Storage Capacity [h]												
$P_{\text{ins}}/P_{\text{rated}}$	6						12					
	1 - Day	2 - Week	3 - Year	1 - Day	2 - Week	3 - Year	1 - Day	2 - Week	3 - Year	1 - Day	2 - Week	3 - Year
1.25	P_{rated}	P_{inst}	CHP1	CHP2								
	250	313	250	63								
	Cumulated Profit / Loss over 10 Years				-173,419 €	-168,892 €	-162,364 €	-267,851 €	-255,338 €	-245,291 €	-308,270 €	-277,155 €
	Average ROI over 10 Years				-7.96%	-7.75%	-7.45%	-9.20%	-8.77%	-8.42%	-9.55%	-8.59%
	Average Additional Revenues per Year over 10 Years				14,499 €	15,010 €	15,663 €	14,499 €	15,751 €	16,755 €	14,499 €	17,610 €
1.5	Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.015	0.015	0.015	0.019	0.019	0.019	0.021	0.021
	P_{rated}	250	375	125	1,75.1.6	1,75.2.6	1,75.3.6	1,75.1.12	1,75.2.12	1,75.3.12	1,75.1.24	1,75.3.24
	Cumulated Profit / Loss over 10 Years				-164,006 €	-156,110 €	-147,386 €	-259,864 €	-231,840 €	-220,300 €	-300,283 €	-249,024 €
	Average ROI over 10 Years				-5.31%	-5.05%	-4.77%	-6.79%	-6.06%	-5.76%	-7.25%	-6.01%
	Average Additional Revenues per Year over 10 Years				24,733 €	25,522 €	26,395 €	24,497 €	27,334 €	28,488 €	24,497 €	29,658 €
2	Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.019	0.019	0.019	0.024	0.023	0.023	0.025	0.025
	P_{rated}	250	500	250	2.1.6	2.2.6	2.3.6	2.1.12	2.2.12	2.3.12	2.1.24	2.3.24
	Cumulated Profit / Loss over 10 Years				-136,747 €	-128,237 €	-112,478 €	-226,875 €	-200,333 €	-175,824 €	-267,294 €	-193,203 €
	Average ROI over 10 Years				-2.98%	-2.79%	-2.45%	-4.26%	-3.76%	-3.30%	-4.73%	-3.42%
	Average Additional Revenues per Year over 10 Years				42,736 €	43,587 €	45,163 €	43,108 €	45,763 €	48,213 €	43,108 €	50,517 €
3	Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.026	0.026	0.026	0.030	0.030	0.030	0.032	0.032
	P_{rated}	250	750	500	3.1.6	3.2.6	3.3.6	3.1.12	3.2.12	3.3.12	3.1.24	3.3.24
	Cumulated Profit / Loss over 10 Years				-187,820 €	-176,254 €	-157,230 €	-268,482 €	-234,963 €	-203,488 €	-308,901 €	-212,140 €
	Average ROI over 10 Years				-2.65%	-2.48%	-2.22%	-3.43%	-3.00%	-2.60%	-3.79%	-2.60%
	Average Additional Revenues per Year over 10 Years				63,089 €	64,245 €	66,148 €	64,407 €	67,760 €	70,907 €	64,407 €	74,083 €
Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.037	0.037	0.037	0.042	0.042	0.042	0.042	0.044	0.044

Table 4.4: Summary Economic Assessment – $P_{\text{rated}} = 550 \text{ kW}_{\text{el}}$

Gas Storage Capacity [h]													
6							12			24			
P _{ins} /P _{rated}	P _{rated}	P _{inst}	CHP1	CHP2	1 - Day	2 - Week	3 - Year	1 - Day	2 - Week	3 - Year	1 - Day	2 - Week	3 - Year
1.25	550	687.5	550	137.5	1,25.1.6	1,25.2.6	1,25.3.6	1,25.1.12	1,25.2.12	1,25.3.12	1,25.1.24	1,25.2.24	1,25.3.24
	Cumulated Profit / Loss over 10 Years				-121,525 €	-111,562 €	-97,203 €	-244,161 €	-216,631 €	-194,531 €	-296,427 €	-260,065 €	-227,975 €
	Average ROI over 10 Years				-3.73%	-3.43%	-2.99%	-5.81%	-5.15%	-4.63%	-6.43%	-5.64%	-4.94%
	Average Additional Revenues per Year over 10 Years				31,898 €	33,023 €	34,458 €	31,898 €	34,651 €	36,861 €	31,898 €	35,534 €	38,743 €
	Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.009	0.009	0.009	0.012	0.012	0.012	0.013	0.013	0.013
1.5	550	825	550	275	1,75.1.6	1,75.2.6	1,75.3.6	1,75.1.12	1,75.2.12	1,75.3.12	1,75.1.24	1,75.2.24	1,75.3.24
	Cumulated Profit / Loss over 10 Years				-61,475 €	-44,106 €	-24,913 €	-187,407 €	-125,598 €	-100,210 €	-239,673 €	-154,228 €	-126,747 €
	Average ROI over 10 Years				-1.26%	-0.91%	-0.51%	-3.22%	-2.16%	-1.72%	-3.85%	-2.48%	-2.04%
	Average Additional Revenues per Year over 10 Years				54,412 €	56,149 €	58,068 €	53,893 €	60,135 €	62,674 €	53,893 €	62,499 €	65,247 €
	Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.013	0.013	0.013	0.015	0.015	0.015	0.017	0.016	0.016
2	550	1100	550	550	2.1.6	2.2.6	2.3.6	2.1.12	2.2.12	2.3.12	2.1.24	2.2.24	2.3.24
	Cumulated Profit / Loss over 10 Years				61,302 €	80,026 €	114,693 €	-51,867 €	6,528 €	60,447 €	-104,132 €	-746 €	58,869 €
	Average ROI over 10 Years				0.81%	1.06%	1.52%	-0.61%	0.08%	0.71%	-1.17%	-0.01%	0.66%
	Average Additional Revenues per Year over 10 Years				94,019 €	95,892 €	99,358 €	94,838 €	100,678 €	106,069 €	94,838 €	105,177 €	111,138 €
	Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.018	0.018	0.018	0.021	0.021	0.021	0.022	0.022	0.022
3	550	1650	550	1100	3.1.6	3.2.6	3.3.6	3.1.12	3.2.12	3.3.12	3.1.24	3.2.24	3.3.24
	Cumulated Profit / Loss over 10 Years				49,224 €	74,669 €	116,521 €	-43,121 €	30,622 €	99,866 €	-95,387 €	30,307 €	117,487 €
	Average ROI over 10 Years				0.41%	0.62%	0.97%	-0.33%	0.24%	0.77%	-0.71%	0.23%	0.88%
	Average Additional Revenues per Year over 10 Years				138,795 €	141,340 €	145,525 €	141,696 €	149,071 €	155,995 €	141,696 €	154,266 €	162,984 €
	Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.028	0.028	0.028	0.030	0.030	0.030	0.031	0.031	0.031

Table 4.5: Summary Economic Assessment – $P_{\text{rated}} = 750 \text{ kW}_{\text{el}}$

Gas Storage Capacity [h]												
	6						12					
	1 - Day	2 - Week	3 - Year	1 - Day	2 - Week	3 - Year	1 - Day	2 - Week	3 - Year	1 - Day	2 - Week	3 - Year
$P_{\text{ins}}/P_{\text{rated}}$												
1.25												
P_{rated}	750	750	750	750	750	750	750	750	750	750	750	750
P_{inst}	937.5	750	187.5	937.5	750	187.5	937.5	750	187.5	937.5	750	187.5
Cumulated Profit / Loss over 10 Years	-76,399 €	-62,813 €	-43,233 €	-212,413 €	-174,871 €	-144,735 €	-212,413 €	-174,871 €	-144,735 €	-270,239 €	-220,654 €	-176,896 €
Average ROI over 10 Years	-1.97%	-1.62%	-1.11%	-4.31%	-3.55%	-2.94%	-4.31%	-3.55%	-2.94%	-5.02%	-4.10%	-3.29%
Average Additional Revenues per Year over 10 Years	43,497 €	45,031 €	46,988 €	43,497 €	47,252 €	50,264 €	43,497 €	47,252 €	50,264 €	43,497 €	48,456 €	52,831 €
Average Additional Electricity Generation Costs over 10 Years [€/kWh]	0.008	0.008	0.008	0.010	0.010	0.010	0.010	0.010	0.010	0.011	0.011	0.011
1.5												
P_{rated}	750	1125	750	750	1125	750	750	1125	750	750	1125	750
P_{inst}	937.5	750	187.5	937.5	750	187.5	937.5	750	187.5	937.5	750	187.5
Cumulated Profit / Loss over 10 Years	23,099 €	46,784 €	72,956 €	-117,481 €	-33,124 €	1,496 €	-117,481 €	-33,124 €	1,496 €	-175,308 €	-58,721 €	-21,247 €
Average ROI over 10 Years	0.39%	0.79%	1.24%	-1.69%	-0.48%	0.02%	-1.69%	-0.48%	0.02%	-2.37%	-0.79%	-0.29%
Average Additional Revenues per Year over 10 Years	74,198 €	76,567 €	79,184 €	73,490 €	82,003 €	85,465 €	73,490 €	82,003 €	85,465 €	73,490 €	85,226 €	88,973 €
Average Additional Electricity Generation Costs over 10 Years [€/kWh]	0.011	0.011	0.011	0.013	0.013	0.013	0.013	0.013	0.013	0.014	0.014	0.014
2												
P_{rated}	750	1500	750	750	1500	750	750	1500	750	750	1500	750
P_{inst}	937.5	750	187.5	937.5	750	187.5	937.5	750	187.5	937.5	750	187.5
Cumulated Profit / Loss over 10 Years	218,640 €	244,173 €	291,446 €	95,537 €	175,166 €	248,691 €	95,537 €	175,166 €	248,691 €	37,710 €	178,692 €	259,984 €
Average ROI over 10 Years	2.36%	2.63%	3.14%	0.92%	1.70%	2.41%	0.92%	1.70%	2.41%	0.35%	1.66%	2.41%
Average Additional Revenues per Year over 10 Years	128,208 €	130,762 €	135,488 €	129,324 €	137,288 €	144,640 €	129,324 €	137,288 €	144,640 €	129,324 €	143,423 €	151,552 €
Average Additional Electricity Generation Costs over 10 Years [€/kWh]	0.016	0.016	0.016	0.018	0.018	0.018	0.018	0.018	0.018	0.019	0.019	0.019
3												
P_{rated}	750	2250	750	750	2250	750	750	2250	750	750	2250	750
P_{inst}	937.5	750	187.5	937.5	750	187.5	937.5	750	187.5	937.5	750	187.5
Cumulated Profit / Loss over 10 Years	247,063 €	281,761 €	338,831 €	152,356 €	252,916 €	347,338 €	152,356 €	252,916 €	347,338 €	94,529 €	265,930 €	384,812 €
Average ROI over 10 Years	1.65%	1.88%	2.26%	0.95%	1.58%	2.17%	0.95%	1.58%	2.17%	0.57%	1.61%	2.34%
Average Additional Revenues per Year over 10 Years	189,266 €	192,736 €	198,443 €	193,222 €	203,279 €	212,720 €	193,222 €	203,279 €	212,720 €	193,222 €	210,363 €	222,250 €
Average Additional Electricity Generation Costs over 10 Years [€/kWh]	0.025	0.025	0.025	0.027	0.027	0.027	0.027	0.027	0.027	0.028	0.028	0.028

Table 4.6: Summary Economic Assessment – $P_{\text{rated}} = 1,000 \text{ kW}_{\text{el}}$

Gas Storage Capacity [h]																	
6					12						24						
P _{ins} /P _{rated}	P _{rated}	P _{inst}	CHP1	CHP2	1 - Day	2 - Week	3 - Year	1 - Day	2 - Week	3 - Year	1 - Day	2 - Week	3 - Year	1 - Day	2 - Week	3 - Year	
					1,000	1,250	1,000	250	1,25.1.6	1,25.2.6	1,25.3.6	1,25.1.12	1,25.2.12	1,25.3.12	1,25.1.24	1,25.2.24	1,25.3.12
1.25	Cumulated Profit / Loss over 10 Years				-13,306 €	4,810 €	30,915 €	-163,103 €	-113,047 €	-72,867 €	-226,615 €	-160,501 €	-102,158 €				
	Average ROI over 10 Years				-0.29%	0.10%	0.67%	-2.84%	-1.97%	-1.27%	-3.63%	-2.57%	-1.64%				
	Average Additional Revenues per Year over 10 Years				57,996 €	60,041 €	62,650 €	57,996 €	63,002 €	67,019 €	57,996 €	64,608 €	70,441 €				
	Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.007	0.007	0.007	0.008	0.008	0.008	0.009	0.009	0.009				
1.5	Cumulated Profit / Loss over 10 Years				139,120 €	170,700 €	205,597 €	-16,847 €	95,711 €	141,870 €	-80,359 €	75,172 €	125,137 €				
	Average ROI over 10 Years				1.96%	2.41%	2.90%	-0.20%	1.16%	1.72%	-0.92%	0.86%	1.43%				
	Average Additional Revenues per Year over 10 Years				98,931 €	102,089 €	105,579 €	97,987 €	109,337 €	113,953 €	97,987 €	113,634 €	118,631 €				
	Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.010	0.010	0.010	0.012	0.011	0.011	0.012	0.012	0.012	0.012			
2	Cumulated Profit / Loss over 10 Years				431,395 €	465,440 €	528,470 €	298,812 €	404,985 €	503,018 €	235,300 €	423,277 €	531,664 €				
	Average ROI over 10 Years				3.82%	4.12%	4.68%	2.40%	3.26%	4.04%	1.82%	3.27%	4.11%				
	Average Additional Revenues per Year over 10 Years				170,944 €	174,349 €	180,651 €	172,433 €	183,050 €	192,853 €	172,433 €	191,231 €	202,069 €				
	Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.015	0.015	0.015	0.016	0.016	0.016	0.017	0.017	0.017	0.017			
3	Cumulated Profit / Loss over 10 Years				519,670 €	565,935 €	642,028 €	424,948 €	559,029 €	684,925 €	361,436 €	589,972 €	748,479 €				
	Average ROI over 10 Years				2.83%	3.08%	3.50%	2.18%	2.86%	3.51%	1.81%	2.95%	3.74%				
	Average Additional Revenues per Year over 10 Years				252,355 €	256,982 €	264,591 €	257,630 €	271,039 €	283,627 €	257,630 €	280,484 €	296,334 €				
	Average Additional Electricity Generation Costs over 10 Years [€/kWh]				0.023	0.023	0.023	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025		

The influence of the varied parameters on the result is discussed below.

Rated Power

Due to the relatively high additional electricity generation costs of the concepts for 250 kW_{el} and 550 kW_{el} it is not possible to reach a positive respectively an economic return. For concepts with a rated power of 750 kW_{el} and 1,000 kW_{el} returns of over 3 % respectively 4 % are achievable.

Ratio $P_{\text{inst}} / P_{\text{rated}}$

The individual ratios of the installed electricity production capacities to the rated power are evaluated as follows:

- 1.25
 - The achieved premium as well as the additional revenues on the electricity market cannot cover the emerging investments. Thus, from an economic point of view this performance ratio is not recommended.
- 1.5
 - The achieved flexible premium as well as the additional revenues on the electricity market cannot cover the emerging investments. Thus, from an economic point of view this performance ratio is not recommended.
- 2
 - The achieved flexible premium as well as the additional revenues on the electricity market can cover the emerging investments. Thus, this performance ratio is recommended.
- 3
 - The achieved flexible premium as well as the additional revenues on the electricity market can cover the emerging investments. Thus, this performance ratio is recommended. Through the design of the flexible premium

(see chapter 3.3.3.2), the effect of the flexible premium decreases at $P_{\text{inst}}/P_{\text{rated}}$ ratios over 2.

Control Strategies

Highly flexible schedules are a decisive factor for the economy of flexible biogas plants. Especially when large gas storage capacities are used.

Gas Storage Volume

Small gas storage capacities can be profitable, if it is not necessary to invest in additional gas storages. The advantage of large gas storages is particularly evident in the case of high installed electricity production capacities. However, an investment in larger gas storage volumes is only profitable, if the electricity production takes place as flexibly as possible.

Capital Costs

The economic efficiency of the concepts with high gas storage capacities fail due to the assumed investment costs for the expansion of the gas storage. In the case of a doubling of the installed electricity production capacity in comparison to the rated power, approx. 68 % - 80 % of the total costs (depending on the rated power) are capital related costs. As an example, the investments assumed for the variants 2-3-6 and 2-3-24 at a rated power of 550 kW_{el} are broken down in figure [Figure 4.8](#).

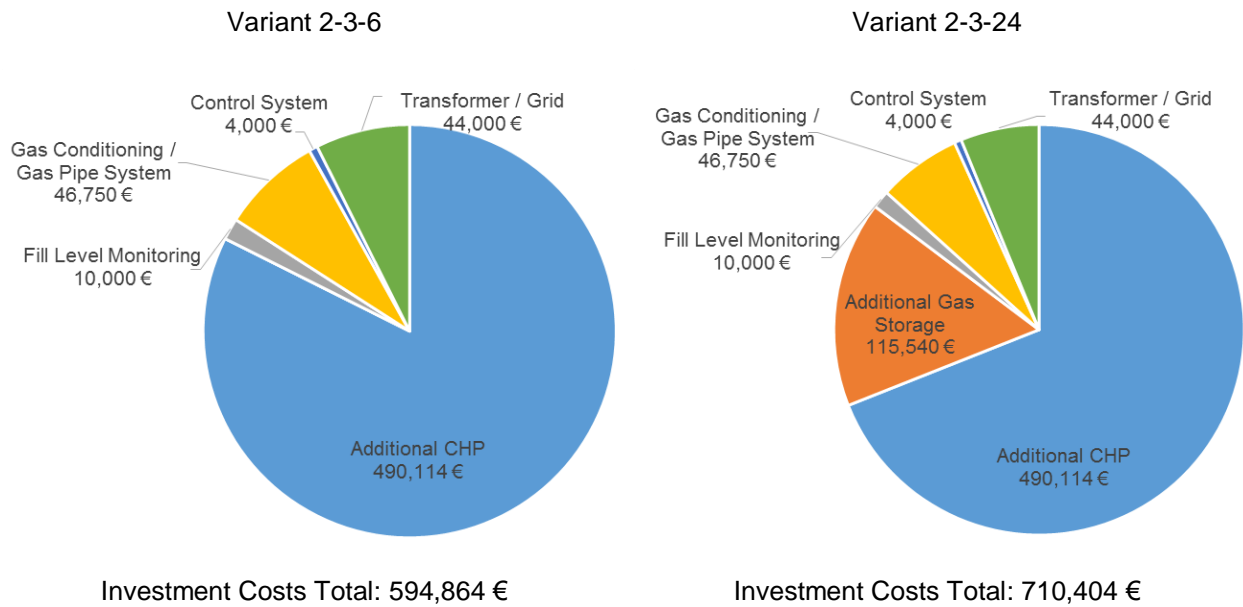


Figure 4.8: Distribution of investment costs for 2-3-6 and 2-3-24

If an existing plant already has larger usable gas storage volumes than assumed, or changes with regard to the grid connection are not necessary, the investments are correspondingly lower. For example, if it is not necessary to invest in additional gas storage capacities and if it also not necessary to add the grid connection, the return on investment of variant 2-3-24 raises from 0.66 % to 4.11 %. This shows how the prerequisites at the respective plants are influencing the economic efficiency of the retrofitting of biogas plants to controllable electricity production.

4.3.3 Summary

The economic efficiency of the plant concepts, considered within the parameter study, has to be classified as moderate. Under the given conditions, it is only possible for concepts with high rated powers of 750 kW_{el} or 1,000 kW_{el} to implement economic effective concepts for the controllable electricity production.

If, contrary to the assumptions, additional investments can be avoided, significantly higher returns are possible.

Especially in the case of large gas storage and high installed electricity production capacities, it is useful to implement as far as possible flexible schedules.

In the end, the economic effectiveness of the controllable electricity production depends on the biogas plant. If appropriate gas storage capacities are already installed, the retrofitting to controlled electricity production is also for economic reasons an option.

5 Implementation and Demonstration of Controllable Electricity Production via Biogas Plants

5.1 Demonstration Plant

For the demonstration of the controllable electricity production, the biogas plant “BG Zellerfeld” ([Table 5.1](#)) was made available. The BG Zellerfeld was built between 2011 and 2012 and is jointly operated by three farmers. The commissioning of the plant took place in 2012.



Figure 5.1: BG Zellerfeld

Digester and post-digester of the plant are designed as a partly subterranean reinforced concrete tanks with a volume of 1,800 m³. The digestate storage-tank is also a partly subterranean reinforced concrete tank, covered by an air supported double layer system as gas storage is used. The digestate storage-tank has a diameter of 32 m and a capacity of 6,400 m³ is the usable flexible volume of the gas storage 2,700 m³

At the commissioning of the plant, a spark-ignition engine with an electrical power of 549 kW_{el} was installed. The engine was operated with a rated output of 500 kW_{el}.

As part of the conversion to the controllable electricity production in 2013, an additional cogeneration plant with an electrical power of 889 kW_{el} was installed. Simultaneously to the commissioning of the additional CHP, the rated output of the biogas plant was increased to 700 kW_{el}. The plant data is summarised in [Table 5.1](#).

Table 5.1: Key Figures of BG Zellerfeld

Rated Power	Approx. 700 kW _{el}	
Installed Power	1.438 kW _{el}	
	CHP 1: 549 kW _{el}	
	CHP 2: 889 kW _{el}	
Usable Gas Storage Volume	2.700 m ³	
	Air Supported Double Layer System	
Used Substrate	Cow Manure	10 %
	Rye Silage (whole plant)	15 %
	Maize Silage (whole plant)	55 %
	Sugar Beet	20 %

Adjustments for the controllable electricity production

As part of the conversion for the controllable electricity production, the gas line, the gas storage and the gas utilisation according to the requirements were adapted to the flexible operation.

As recommended in Chapter 3.2.2.2, both CHP units are equipped with a pre-heating and pre-lubrication system. The pre-heating consist of an electric heater and a water pump integrated in the primary water circuit of the CHPs. During standstill of the engine, the temperature of the coolant is kept constantly at about 60 °C. The pre-lubrication consist of an oil pump, integrated in the oi circulation of the engine. The pump starts to build up the oil pressure 1 minute before the start of the engine. In order to cool down the turbochargers, the oil pressure is held 15 minutes after the engine stop.

The fuel supply for both engines takes place via separate gas lines incl. gas drying gas cooler and fine desulphurisation via activated carbon. To ensure the quality of the gas at the CHPs, the gas line gets purged with purified gas from the gas storage prior to the CHP start.

For the temporary storage of the gas, the existing air supported double layer gas storage over the digestate storage tank with an usable volume of 2,700 m³ is used. With the installation of additional gas utilisation capacities, the maximum gas extraction rises from about 250 Nm³_{Biogas}/h to about 750 Nm³_{Biogas}/h. So the capacity of the air blower, which provides

the supporting air for the gas storage was adjusted accordingly in order to ensure the stability of the tank cover.

The existing rope system for the measurement of the gas storage fill level was supplemented by a water gauge system as described in Chapter 3.1.1.3 with three water gauges.

5.2 Operation and Electricity Production Concept

Aim of the controllable electricity production at the BG Zellerfeld is to achieve a higher remuneration for the produced electricity by the use of the market bonus scheme, introduced under the EEG 2012 and the gained possibility of the direct trading. For this purpose the produced electricity is traded via an electricity trader.

To achieve higher remunerations for the plant operators the gas utilisation capacities were increased as described. By taking advantage of the gas storage capacities, it is possible to adapt the electricity production of the demonstration plant on the control instrument, the electricity market.

The created flexibility of the plant can be described as below:

- The usable gas storage volume of 2,700 m³ is sufficient to store the gas production of 6 h at a related to rated output of 700 kW_{el}.
- With the installed power capacity, the full gas storage can be emptied within approx. 6 h. Thereby, the further gas production within this period is taken into account.

Based on the methodology described in chapter 4.2, optimised schedules for the BG Zellerfeld were created, which are taking the technical possibilities of the components and the installed infrastructure into account. Figure 5.2 shows a developed electricity production schedule of the BG Zellerfeld and the resulting fill level of the gas storage for a single day.

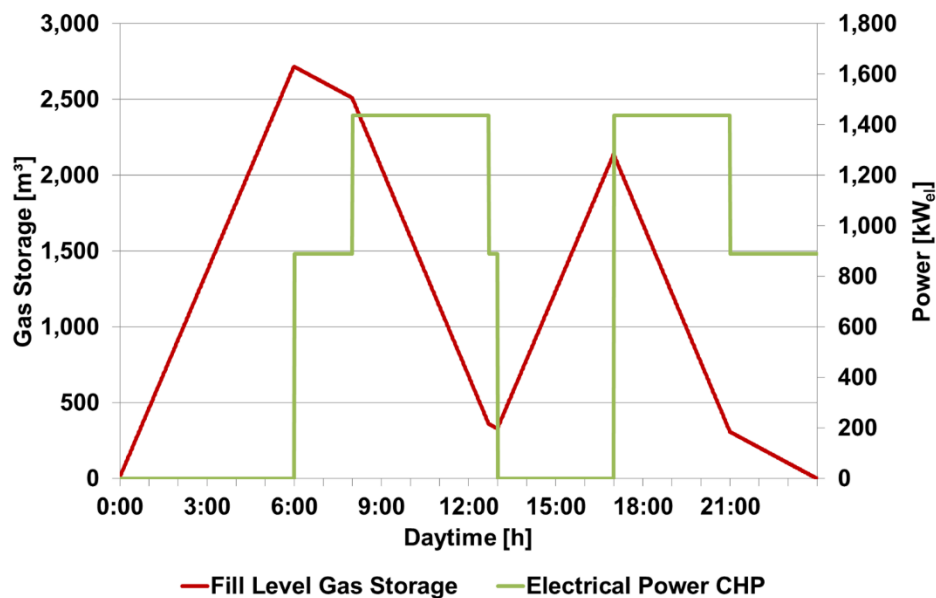


Figure 5.2: Optimised Schedule of BG Zellerfeld

The input of the schedule is done manually by the plant operators in consultation with the electricity trader via the system control. So the schedule can be individually adapted to the current electricity prices, the current gas production or CHP maintenances. The settlement with the electricity trader takes place via the $\frac{1}{4}$ -hour measurement of the registered power measurement of the energy supplier.

The BG Zellerfeld shares the grid connection point with several ground-mounted PV plants with a total maximum feed-in power of 5,000 kW_{el}. These PV plants are also operated by the operators of the BG Zellerfeld. With the total feed-in power of the biogas plant of 1,438 kW_{el} there are in total 6,438 kW_{el} attached to the grid connection point.

As shown in [Figure 5.3](#) the shared grid connection point is designed for a maxim feed in of 5,000 kW_{el}. Thus, the capacity of the connection point is too low to ensure a simultaneous maximum feed-in of the biogas plant and the ground-mounted PV system.

Since an expansion of the capacity of the grid connection point during the duration of the project could not be realised, it was necessary to take the feed-in of the PV system into account within the scheduling of the electricity production of the biogas plant.

For this reason, the flexibility of the electricity production is limited during periods of high solar loads. Thus, a purely electricity market optimised schedule was not possible during the monitoring.

Within the preparation of the implemented schedules the restriction by the grid connection point is taken into account according the sunshine duration and sunshine intensity as described below:

- During times of high radiation intensity, only the smaller CHP 1 with a nominal output of 549 kW_{el} is operated.
- In the summer months the power of the CHP1 is additionally limited to 450 kW_{el} during noon.

The consideration of the ground-mounted PV system in the schedules is done manually and not foresightedly. Thus, unexpected overloads of the grid connection point occurred partially. Beyond this limitation, the electricity production is carried out optimised regarding the electricity prices as described.

To illustrate the flexible plant operation at the BG Zellerfeld with the limitation by the grid connection, [Figure 5.4](#) shows measured values from the monitoring which are representing a schedule of the electricity production at a current rated power of 860 kW_{el}. For this exemplary day the electricity production was limited in order to avoid an overload of the grid connection point to a maximum of 549 kW_{el} between 9 am and 6 pm. This restriction results in the shown schedule, optimised regarding the electricity prices at the day-ahead auction of the EPEX Spot SE.

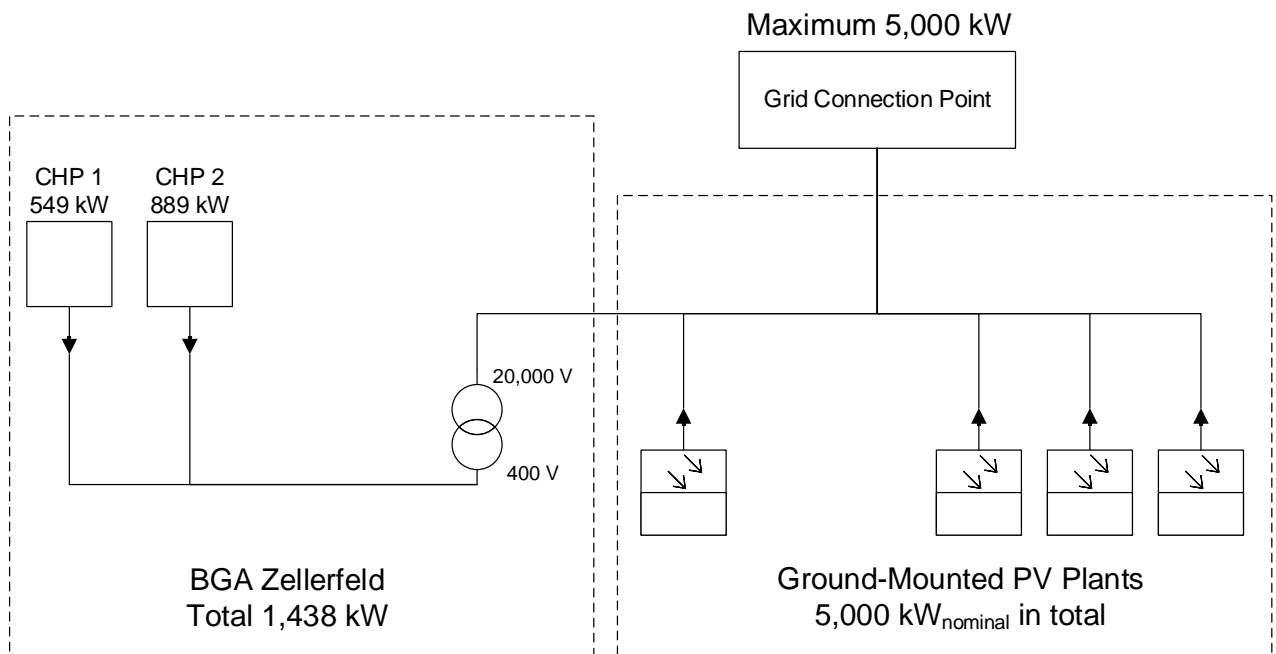


Figure 5.3: Schematic Illustration of the Grid Connection of BG Zellerfeld

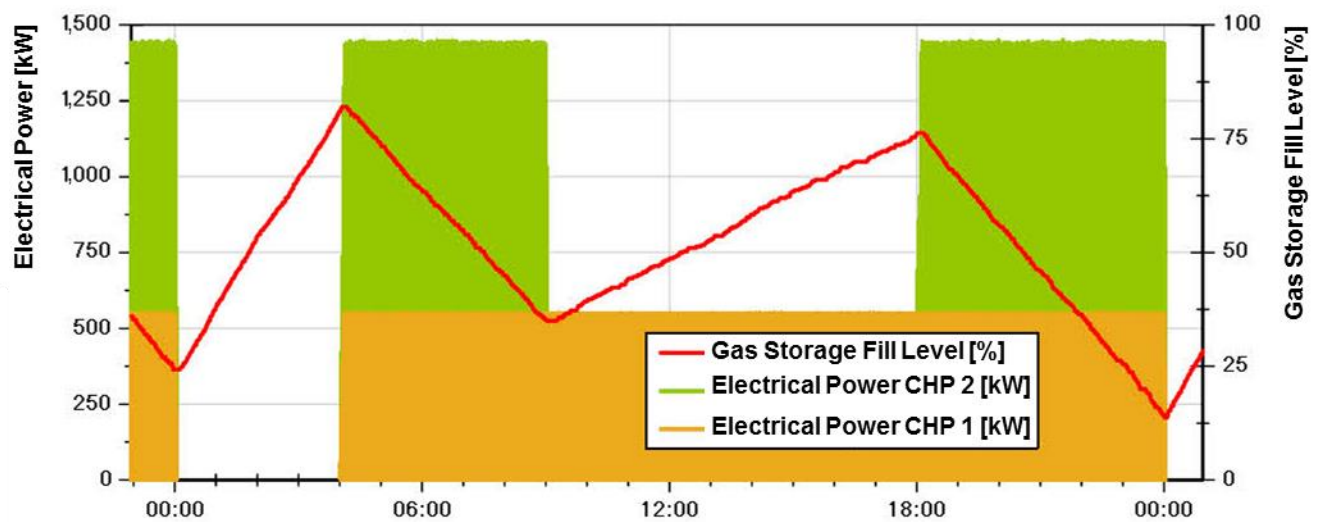
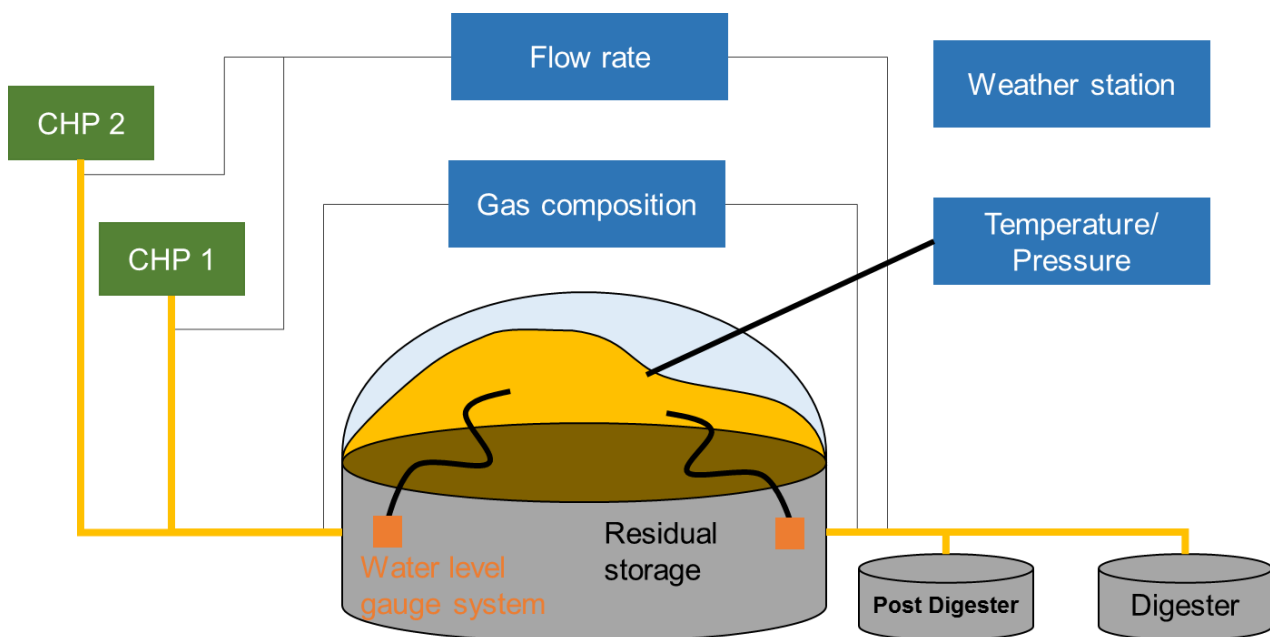


Figure 5.4: Illustration of a Schedule of BG Zellerfeld via real measured values (08/13/2014)

5.3 Monitoring

Aim of the monitoring at the demonstration plant is to ensure the effectiveness of the implemented measures and the analysis of the potential and limitations of the affected components, in order to enable an optimisation of the controllable electricity production during practical operation

For this purpose, in the course of the project extensive measurement technology has been installed at the demonstration plant, which allows a detailed scientific monitoring of the controllable electricity production. The measurement concept is schematically illustrated in [Figure 5.5](#).



[Figure 5.5](#): Schematic Illustration of the Measurement Concept

Core of the monitoring is the analysis of the gas storage. For the measurement of the gas storage fill level the water level gauge system described in chapter 3.1.1.3, with three water level gauges is used. Additionally the fill level is measured with the rope system, which was installed before the conversion to the controllable electricity production. So, a comparison between these two systems is possible.

In addition to the fill level monitoring the in- and outflowing biogas of the biogas storage is accounted. For this purpose the composition and the volume flow of the biogas are measured as illustrated in [Figure 5.5](#). The composition of the biogas (share of CH_4 , CO_2 and O_2) is measured directly before and after the gas storage. The measurement of the volume

flow takes place by using thermal gas flow meters. In order to account the two CHP units individually, the respective volume flow is recorded before each CHP.

For the final accounting of the in- and outflowing amounts of energy, the water content of the biogas at the mass flow meters is compensated via the consideration of the gas temperature (see chapter 3.2.1.1). The measurement of the temperature for the dew point determination of the incoming biogas takes place just before the gas storage. The determination of the water content of the CHP side of the gas storage is measured directly after the gas cooling unit of the gas drying system.

For the standardisation of the gas storage content as described in Chapter 3.2.1.1, the temperature of the gas in the gas storage is measured in the middle of the freeboard (space between the maximum fill level of the residue in the tank and the beginning of the usable gas storage space) approximately 1.5 m away from the inner wall of the tank. In addition, the absolute gas pressure in the gas storage is recorded for the standardisation.

In order to assess the impact of environmental conditions on the conditions in the gas storage, a weather station was installed at the plant. The ambient temperature, the relative humidity, the atmospheric pressure, the solar radiation and the wind speed are recorded at the altitude of the gas storage.

In addition, the temperature of the substrate as well as the gas pressure conditions in all of the tanks are measured in order to be able to analyse corresponding effects on the controllable electricity production.

To give evidence regarding the electricity production, the current generation of each CHP unit is recorded. Therefore the recorded values of the control unit of the CHP units are used.

5.4 Monitoring Results

5.4.1 CHP Operation

The histogram in [Figure 5.6](#) shows the relative frequency of the height of the current electricity production for the period from 07/01/2014 to 11/30/2014 (class width: 10 kW_{el}).

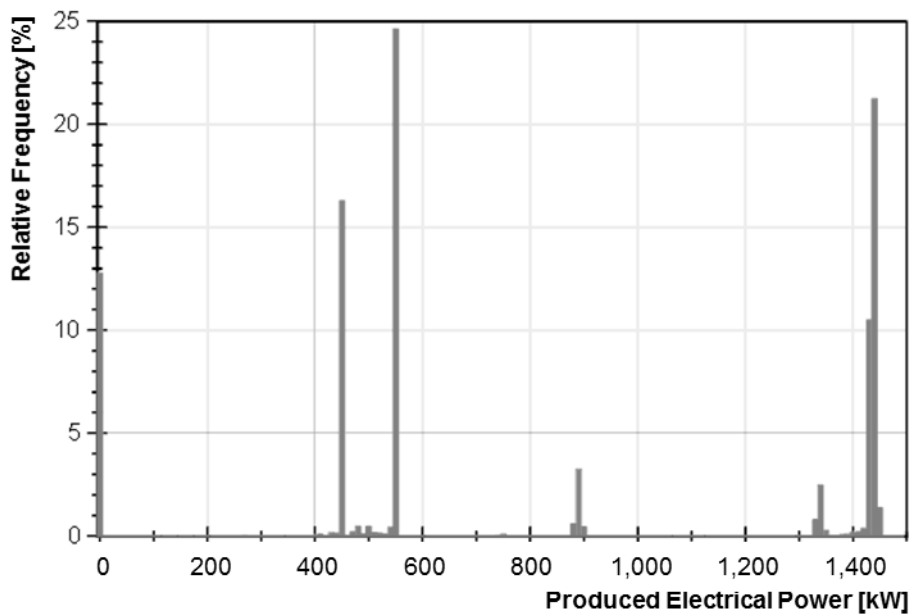


Figure 5.6: Histogram of the current electricity production at BG Zellerfeld (07/01/2014 to 11/30/2014)

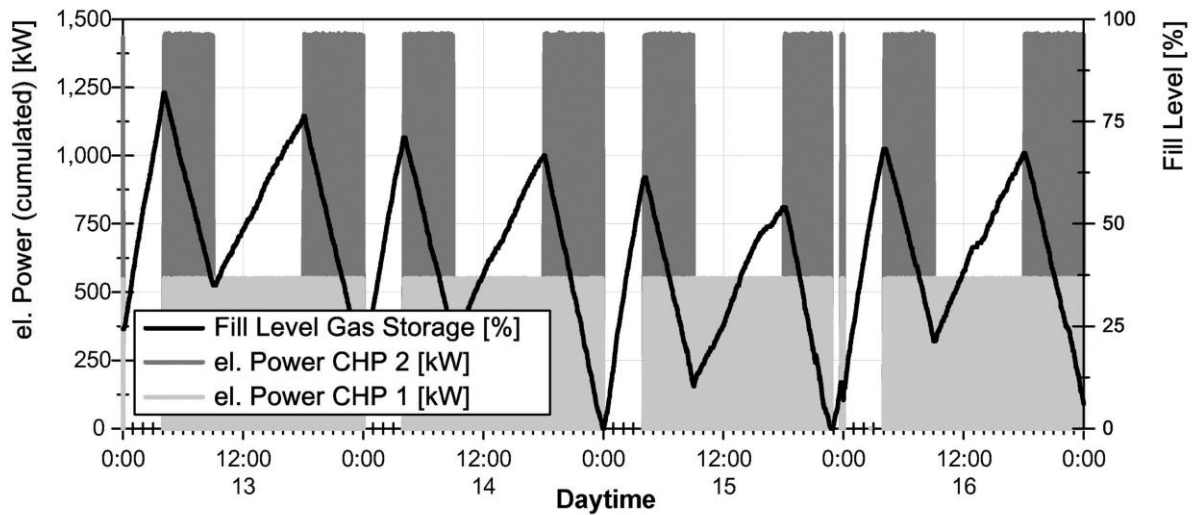
The main areas of the power production are confirming the implemented concept of the controllable electricity production described in Chapter 5.2. The histogram shows how many times during the considered period which power has been produced in total. At 12.8 % of the time no electricity was produced. That means, that in the considered period the power generation has been suspended for 3 hours a day on average. Overall, 43.1 % of the measured values are in the range of 450 and 550 kW_{el} and 33.1 % between 1,400 and 1,500 kW_{el}.

The visualisation of the produced electric power shows that the schedules entered from the operators can be reliably retraced.

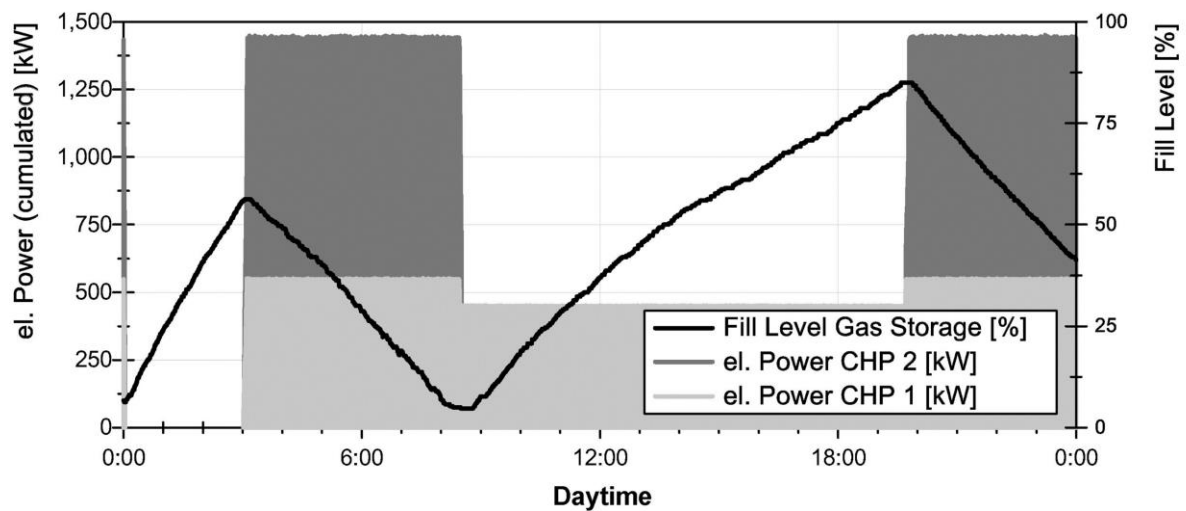
Figure 5.7 illustrates, representative for the normal operation of the controllable electricity production at the demonstration plant, the generated power and the current gas storage level between the 13th and 16th of August 2014. In comparison to that, Figure 5.8 shows an example of the operation of the electricity production at a day with high solar radiation. The rated power during the time periods shown in Figure 5.7 and Figure 5.8 were each about 800 kW_{el}.

To compensate the low utilisation of the electricity production during the conversion of the demonstration plant for the controllable electricity production, the rated power of the plant was temporarily raised to 975 kW_{el} in order to produce the originally planned yearly amount

of electricity. The corresponding operation schedule of the demonstration plant is illustrated in [Figure 5.9](#).



[Figure 5.7](#): Normal Operation of BG Zellerfeld (August 13 to 16 2014)



[Figure 5.8](#): Operation of BG Zellerfeld at High Solar Radiation (Juli 20 2014)

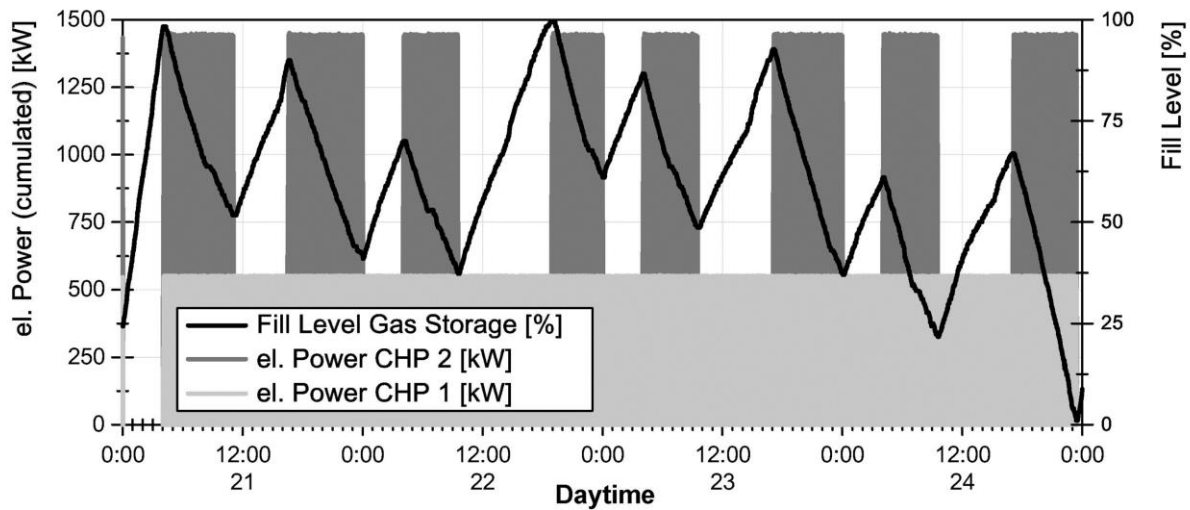


Figure 5.9: Operation at Raised Rated Power (November 21 to 24, 2014)

The starts of the two CHP units were consistently reliable during the monitoring period. To assess the starting behaviour a typical start and shut down process of the two CHP is shown in [Figure 5.10](#). The load increase of the after the power requirement of both CHP at 3:00 pm begins after the synchronisation of the generators to the electricity grid. CHP 1 needs 45 seconds for the synchronisation, whereas CHP 2 starts after 90 seconds. The load increase of CHP 1 is carried out with about $2.5 \text{ kW}_{\text{el}}/\text{second}$, that of CHP 2 with about $32 \text{ kW}_{\text{el}}/\text{second}$. The nominal load of CHP 1 is achieved after 5 minutes and 15 seconds after the power requirement. The larger CHP 2 reaches the nominal load after 6 minutes and 5 seconds after the requirement.

For a prequalification for the participation in the secondary balancing power market (Chapter 3.3.2) the start-up procedure of both CHP units lasts too long to with the currently set ramps for load increase. However, it is possible to adapt these ramps in agreement with the CHP manufacturer.

The switch-off of both CHP units of both CHP units is completed after 2 minutes and 55 seconds. The load reduction at CHP 1 is carried out with $3.1 \text{ kW}_{\text{el}}/\text{second}$ at CHP 2 with $5.1 \text{ kW}_{\text{el}}/\text{second}$.

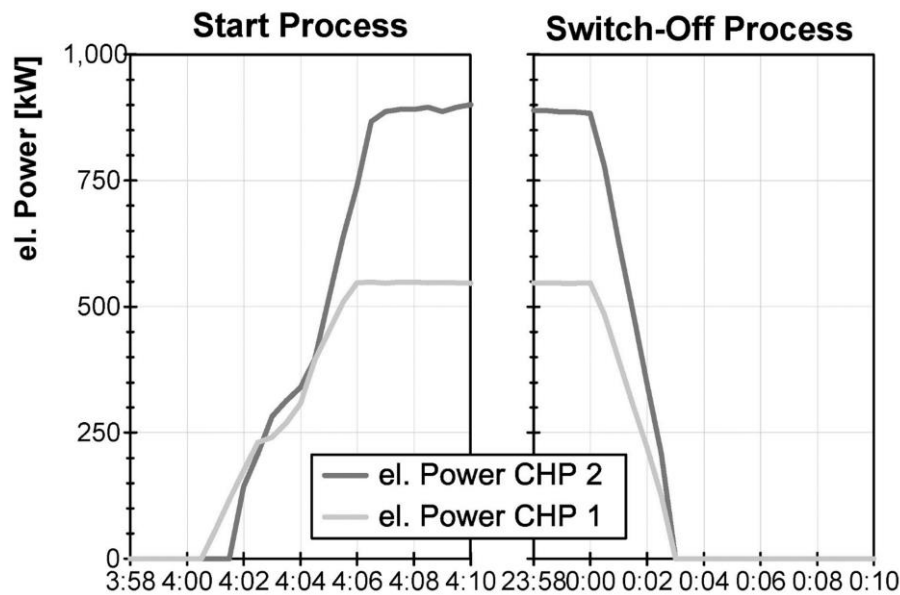


Figure 5.10: Electrical power during Start and Switch-Off Process

The volume rates collected in the course of the monitoring and the detection of the gas composition enables an assessment of the electrical efficiencies of the CHP. The efficient value calculated from the measured values at nominal load at CHP 1 is between 39.5 and 40 %, that of CHP 2 between 43 and 44 %. With that, the electrical efficiency of CHP 1 is slightly lower as the value specified in technical data sheet of CHP 1 of 40.7 %. In the technical data sheet of CHP 2 an electrical efficiency of 42 % is given. Thus the measured values of CHP 2 are between 1 and 2 percentage points higher than the specifications of the manufacturer.

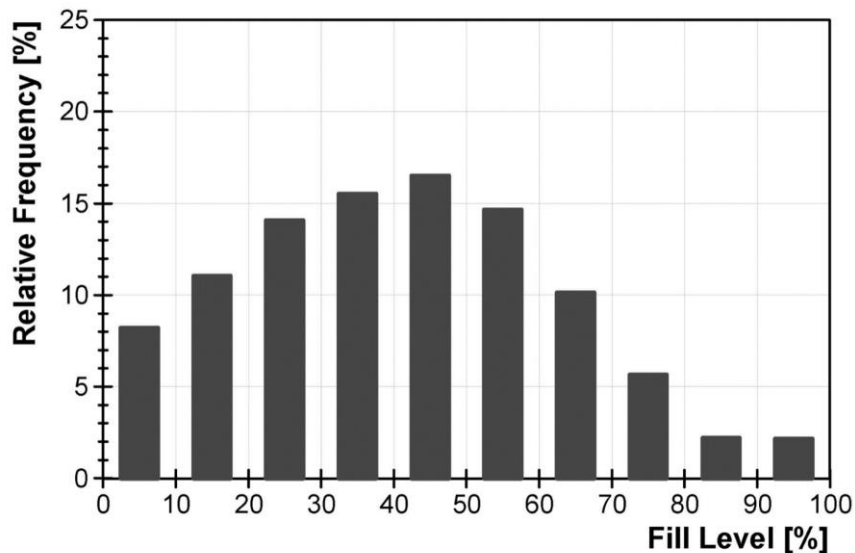
As described, CHP 1 is temporarily operated in partial load with an electrical power output of 450 kW_{el} (82 % of the nominal load). During the operation in partial load, the measured electrical efficiency decreases at about 1.5 percentage points to 38...38.5 %.

5.4.2 Gas Storage Operation

The objective of the gas storage operation within the controllable electricity production is to exploit the available gas storage volume completely and evenly as possible. Due to the limitations through the grid connection point of the demonstration plant the flexibility of the electricity production is limited. So the schedules of electricity production could not be fully optimised for the available storage volume. The histogram in [Figure 5.11](#) illustrates the

utilisation of the available gas storage at the demonstration plant for the period between 07/01/2014 and 11/30/2014.

As clearly can be seen, the gas storage was not used evenly. The fill level of the storage are far more frequently in the range of 0 and 40 % than in the range between 60 and 100 %. Fill levels between 80 and 100 % are exploited only sporadically. The typical time course of the gas storage fill level is illustrated in [Figure 5.7](#), [Figure 5.8](#) and [Figure 5.9](#).



[Figure 5.11](#): Histogram of the Gas Storage Usage of BG Zellerfeld (07/01/2014 to 11/30/2014)

That the available gas storage Volume is not fully utilised leads to a relatively frequent (on approx. 20 % of the days in the considered period) shutdown of the electricity production due to an underrun of the minimum gas storage volume of 5 % of the usable volume which is set in the system control. The shutdown is necessary to avoid negative pressure in the gas storage. Such a security shut down of the electricity production is illustrated in [Figure 5.7](#) on August the 15th shortly before 11 pm.

The bad utilisation of the gas storage can be attributed to an inadequate adaption of the feeding quantity of the digester and thereby the produced amount of biogas at the defined rated power of the electricity production on which the schedules are based.

5.4.3 Gas Storage Conditions

Since the volume of gases depends on pressure and temperature, it is necessary for the comparison of biogas yields, biogas volume information and statements about the amount of stored energies to refer these to standard conditions (see Chapter 3.2.1.1). Therefore, the temperature of the gas in the gas storage has a great influence on the storable energy.

[Figure 5.12](#) and [Figure 5.13](#) show the temperature of the gas in the gas storage at the warmest and coldest day of the year. In order to show the influence of environmental conditions on the temperature of the gas in the storage, the ambient temperature, the temperature of the substrate in the residual storage tank, the temperature of the incoming gas from the digesters and the solar radiation are visualised.

Generally, the temperature of the stored gas follows the ambient temperature, in summer as well in winter.

The gas temperature in the gas storages does not exceed the temperature of the incoming gas at any time. At warm weather condition during times of high solar radiation the temperature of the incoming gas, which is flowing through above ground laid gas pipes made of stainless steel, rises partially by 5 °C because of the radiation. At cold ambient conditions the incoming gas tends to the ambient temperature. The temperature in the gas pipes between the digesters and the gas storage cool down by 15 °C in comparison to the gas temperature in the digesters to about 25 °C.

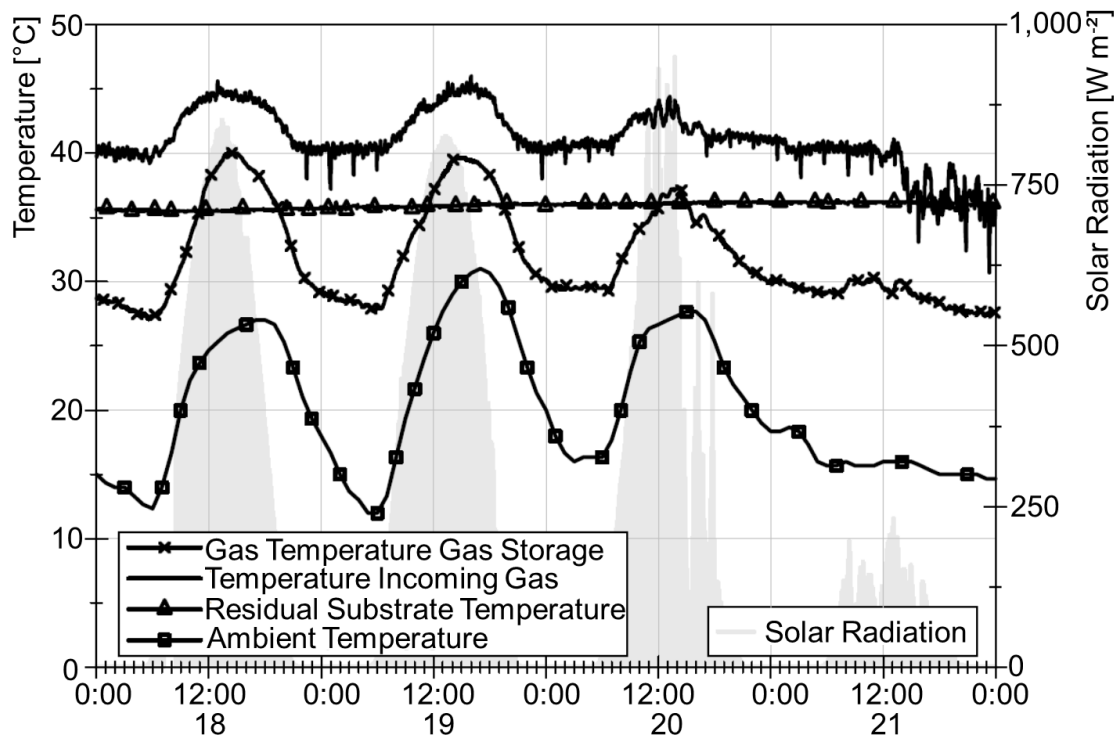


Figure 5.12: Temperature in the Gas Storage and Influencing Factors (July 18 to 21 2014)

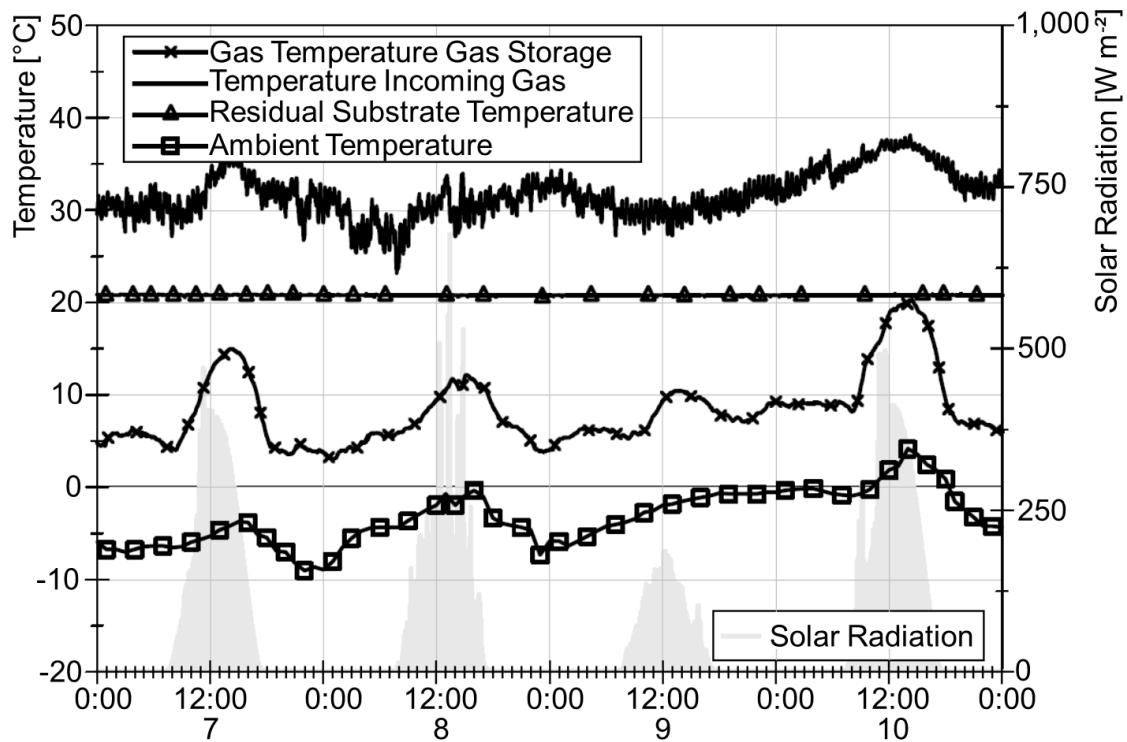


Figure 5.13: Temperature in the Gas Storage and Influencing Factors (February 7 to 10 2015)

The highest during the monitoring measured gas temperature in the storage was measured on 18 July 2014 ([Figure 5.12](#)) with 40 °C. The theoretical maximal storable standard volume at this time was 2,133 Nm³. This corresponds to 79 % of the absolute value of the usable volume. The lowest temperature of the gas in the gas storage as 3 °C on February 8, 2015 ([Figure 5.13](#)). Based on the conditions at this time it results in a theoretical maximal storable standard volume of 2,570 Nm³ (about 95 % of the absolute value of the usable Volume). Thus, at very cold outdoor conditions up to 20 % more energy can be stored in the gas storage as in comparison to very warm ambient conditions. During the day the storable standard volume varies in summer as well in winter by up to 170 Nm³.

A separation of the individual components of the gas in the gas storage could not be detected with the installed measurement equipment. However, the methane content increases in the gas storage, which is installed above the residual storage tank, by between 0 and 1 percentage points compared to methane content of the biogas from the digesters. This increase is attributable to the biogas, which arises in the digestate storage tank.

5.4.4 Gas Storage Management

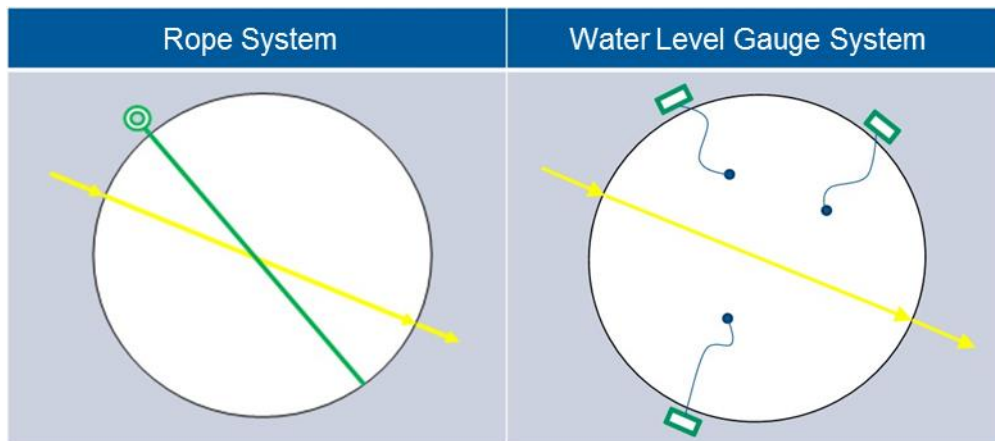
An increased focus in the case of the demand oriented biogas utilisation must be given to the gas storage management. Aim of the gas storage management is to control the current situation of the storage with sufficient accuracy.

It must be ensured that the produced gas can be stored respectively utilised at any time. At the same time the scheduled demand must be covered. In order to produce demand oriented electricity, the produced amount of gas, the stored amount of gas as well as the gas demand must be known at any time.

At the air supported double layer system, which is used at the demonstration plant, the measurement of the fill level of the storage takes place via the measurement of the position of the inner gas storage membrane. Since the pressure in the gas storage space and in the space between inner and outer membrane is almost identical, the gas storage membrane can be formed irregular in different shapes depending on the currents in the gas storage space and the supporting air space. This is a challenge for the different measuring methods for determining the position of the inner membrane, described in Chapter 3.1.1.3.

At the demonstration plant, a rope system and a water level gauge system with three water level gauges are installed. Thus it is possible to make a direct comparison of both systems.

As illustrated in [Figure 5.11](#), the rope of the rope system is lead in a straight line over the centre of the storage, whereas the three water level gauges are fixed even around the centre gas storage. The measured values of each water level gauge are averaged together.



[Figure 5.14](#): Schematic Illustration of the Positioning of the Installed Fill Level Monitoring Systems

[Figure 5.15](#) shows a direct comparison of the two systems. In the illustration an adjustment of the measured values of the rope system is shown. It is clearly evident that shortly after the adjustment, the lower fill level as well as the upper fill level of the rope system is up to 20 percentage points lower than the values of the water level gauge system. This shows how difficult it is to interpret the values of the rope system.

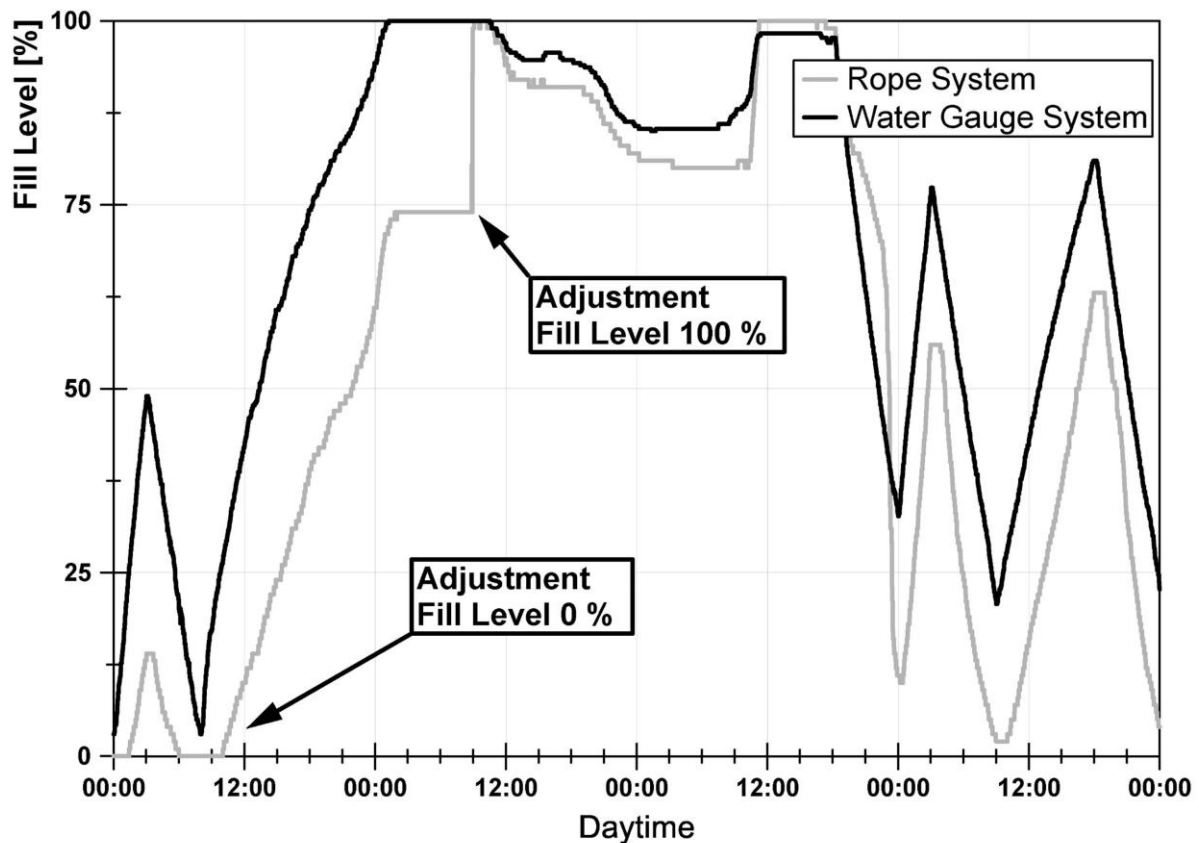


Figure 5.15: Comparison of the Rope System and the Water Level Gauge System

This can be attributed to possible existing bulges of the inner membrane which are not detected by the rope. A controlled operation of the electricity production just by means of the installed rope system would not be possible due to these uncertainties.

The measured values of the water level gauge system were throughout plausible during the monitoring period.

The operating pressures of the gas storage were in a permissible area for the operation of the gas storage at any time. This indicates, that it is proved that the fill level limits, which are set in the system control of 5 % respectively 95 % of the fill level, are adequate.

Overall, it can be stated that the exact knowledge of the measurement characteristics of the systems for the fill level monitoring and the conditions in the gas storage at different ambient conditions allows a better utilisation of the available gas storage volume for the purposes of the controllable electricity production. Thus, safety buffers can be reduced and the flexibility of the electricity production can be exhausted.

6 Conclusions and Discussion

The conducted investigation and demonstration shows, that through the temporarily storage of the produced gas, biogas plants are technically able to shift the electricity production in a way, which can compensate fluctuating and supply-dependent electricity production from wind and photovoltaics. The spot markets of EPEX Spot SE could be identified as a suitable control instrument.

The developed plant concepts and control strategies enables the in Nitsch et al. (2012) described use of electricity production for the covering of high residual loads in a renewable based future electricity system.

For the conversion of regular biogas plants into controllable electricity producers an investing in additional electricity production capacities, investments in gas storage capacities and measuring equipment can be necessary. This coincides with the more theoretical work of Gerhardt (2009) and Szarka et al. (2013).

The costs determined in the context of the concept development are corresponding with the costs determined in Schmid et al. (2009), Hartman et al. (2010), Rohrig et al. (2011) and Keymer (2013).

The effort to convert the operation concept must be considered in individual cases and is highly system-specific. Under the current subsidies and under certain conditions, it can be economical reasonable to implement concepts for controllable electricity production.

To ensure a reliable operation and economic success following recommendations are given.

6.1 Recommendations regarding technical Equipment

- To ensure a reliable intermittent operation of CHP units, it is recommended to use preheating and pre-lubrication systems.
- For the biogas storage, air supported double layer systems are recommended as most suitable for the controlled electricity production. They enable the largest usable storage volumes and the most accurate fill level measurement.
- For the gas storage management and an optimum utilisation of the gas storage capacities, as accurate as possible level monitoring systems are indispensable. A suitable system for filling level monitoring at air supported double layer systems water gauge systems with several measuring points on the storage membrane can be recommended.

6.2 Recommendations regarding Concepts and Operation

- An intermittent operation of the CHP units in full load is preferable to partial load operation from an economic and ecological point of view.
- Plant concepts with at least a doubling of the installed electricity production capacities in comparison to the rated power can be classed as economic meaningful.
- The more flexible the schedule of the electricity production is adjusted to the current electricity prices, the higher the additional revenues and the more meaningful larger gas storages can be utilised.

6.3 Outlook

Currently, the controllable electricity production is only possible due to the effort of the plant operators. For a high degree of acceptance of future concepts by the plant operators an extensive automation of the electricity production schedule implementation is necessary. It must be ensured, that the plant operator retains the final control over his plant.

In order to achieve a higher degree of flexible electricity production via biogas plants, besides the on-site gas storage, the gas production must be made more flexible. Due to the low necessary additional investment in further technical equipment the use of the range of energy content and degradability of various substrates seems to be promising.

The flexibility of the controllable electricity production can also be used for other aims than the stabilisation of the residual load. One promising aim is a heat-controlled operation of biogas plants. The heat-controlled operation of biogas plants can be carried out analogue to the controllable electricity production on a daily or weekly base. Also a season-dependent heat production could be a feasible way for the energy production via biogas plants.

References

AGORA ENERGIEWENDE (2015) *Agorameter* [WWW] Agora Energiewende. Available from: http://www.agora-energiewende.de/service/aktuellestromdaten/?tx_agoragraphs_agoragraphs%5BinitialGraph%5D=powerGenerationPrice&tx_agoragraphs_agoragraphs%5Bcontroller%5D=Graph [Accessed: 18/02/2015].

AMPIRON (n.d.) *Primärregelung, Sekundärregelung, Minutenreserve* [WWW] Amprion. Available from: <http://www.amprion.de/primaerregelung-sekundaerregelungminutenreserve> [Accessed: 21.03.2012].

ARBEITSGEMEINSCHAFT FÜR SPARSAMEN UND UMWELTFREUNDLICHEN ENERGIEVERBRAUCH e.V (ASUE) (Ed.) (2010) *BHKW Grundlagen*. Berlin: Arbeitsgemeinschaft für sparsamen und umweltfreundlichen Energieverbrauch e.V (ASUE).

ARBEITSGEMEINSCHAFT FÜR SPARSAMEN UND UMWELTFREUNDLICHEN ENERGIEVERBRAUCH E.V. (ASUE) (Ed.) (2011) *BHKW Kenndaten 2011*. Berlin: Arbeitsgemeinschaft für sparsamen und umweltfreundlichen Energieverbrauch e.V (ASUE).

ASUE Ed.) (2014) *BHKW-Kendaten 2014/15*. Berlin: Arbeitsgemeinschaft für sparsamen und umweltfreundlichen Energieverbrauch e.V. (ASUE).

BÄR, K. (2016) *Simulationsbasierte Optimierung der Fahrweise von Biogasanlagen*. Thesis (MSc.), Technische Hochschule Ingolstadt.

BARZANTNY, K. ACHNER, S and VOMBER, S. (2009) *Klimaschutz: Plan B 2050 – Energiekonzept für Deutschland*. Hamburg: Greenpeace.

BIOGASPARTNER (n.d. a) Market Development in Europe [WWW] German Energy Agency. Available from: <http://www.biogaspartner.de/en/europe/market-development.html> [Accessed: 18/02/14].

BIOGASPARTNER (n.d. b) Biomethane Injection Projects in Germany [WWW] German Energy Agency. Available from: <http://www.biogaspartner.de/en/project-map/list-of-projects-in-germany.html> [Accessed: 18/02/14].

BAYERISCHES LANDESAMT FÜR UMWELT (BLU) (Ed.) (2007) *Biogashandbuch Bayern – Materialienband* [WWW] Bayerisches Landesamt für Umwelt. Available from: <http://www.lfu.bayern.de/abfall/biogashandbuch/doc/kap1bis15.pdf> [Accessed: 31/10/2013]

BUNDESMINISTERIUM FÜR WIRTSCHAFT UND ENERGIE (BMWi) (2015) *Zeitreihen zur Entwicklung der Erneuerbaren Energien in Deutschland* [WWW] BMWi. Available from: http://www.erneuerbare-energien.de/EE/Redaktion/DE/Downloads/zeitreihen-zurentwicklung-der-erneuerbaren-energien-in-deutschland-1990-2013.pdf?__blob=publicationFile&v=13 [Accessed: 18/02/2015]

CENO MEMBRANE TECHNOLOGY GmbH (n.d.) *Biogasspeicher* [WWW] Ceno Membrane Technology GmbH. Available from: http://www.sattler-ag.com/sattler-web/static/media/pdf/Broschuere_UT_DE.pdf [Accessed: 03/11/2013].

DEUTSCHES BIOMASSE FORSCHUNGSZENTRUM (DBFZ) (Ed.) (2012) *Monitoring zur Wirkung des Erneuerbare-Energien-Gesetz (EEG) auf die Entwicklung der Stromerzeugung aus Biomasse – Endbericht zur EEG-Periode 2009 bis 2011*. Leipzig: Deutsches Biomasse Forschungszentrum (DBFZ).

DEUTSCHES BIOMASSE FORSCHUNGSZENTRUM (DBFZ) (Ed.) (2013) *Stromerzeugung aus Biomasse 03MAP250 - Zwischenbericht*. [WWW] Deutsches Biomasse Forschungszentrum (DBFZ) Available from: http://www.erneuerbare-energien.de/fileadmin/Daten_EE/Dokumente__PDFs_/biomassemonitoring_zwischenbericht_bf.pdf [Accessed: 08/02/14].

ENGELHARD, O. (1999) *Dieselmotorenanlagen*. 1st ed. Würzburg: Vogel Verlag und Druck GmbH&Co. KG.

EUROOBSERV`ER (2012) Biogas barometer. [WWW] le journal des énergies renouvelables. Available from: <http://www.euroobserv-er.org/pdf/baro212biogas.pdf> [Accessed: 15/02/14].

FACHAGENTUR NACHWACHSENDE ROHSTOFFE e.V. (Ed.) (2009) *Biogas-Messprogramm II 61 – Biogasanlagen im Vergleich*. Gülzow: Fachagentur Nachwachsende Rohstoffe e.V. (FNR).

FACHAGENTUR NACHWACHSENDE ROHSTOFFE e.V. (Ed.) (2010) *Leitfaden Biogas von der Gewinnung zur Nutzung*. 5th ed. Gülzow: Fachagentur Nachwachsende Rohstoffe e.V. (FNR).

FACHAGENTUR NACHWACHSENDE ROHSTOFFE e.V. (Ed.) (2013) *Leitfaden Biogas von der Gewinnung zur Nutzung*. 6th ed. Gülzow: Fachagentur Nachwachsende Rohstoffe e.V. (FNR).

FEDERAL MINISTRY FOR ECONOMIC AFFAIRS AND ENERGY (2010) *Energiekonzept für eine umweltschonende, zuverlässige und bezahlbare Energieversorgung* – 28. September 2010. Berlin: German Federal Ministry for Economic Affairs and Energy.

FEDERAL MINISTRY OF JUSTICE (2012) *Gesetz für den Vorrang Erneuerbarer Energien (Erneuerbare-Energien-Gesetz - EEG)* [WWW] German Federal Ministry of Justice. Available from: http://www.gesetze-im-internet.de/bundesrecht/eeg_2009/gesamt.pdf [Accessed 17/01/14].

Foliengasspeicher (n.d.) [Online Image] BAUR FOLIEN GmbH. Available from: <http://www.baur-folien.de/docs/gasspeicher.php> [Accessed: 25/04/2012].

FORUM NETZTECHNIK UND NETZBETRIEB IM VDE (FNN) (Ed.) (2009) Transmission Code 2007 Anhang D2 Teil 2 Anforderungen für die Umsetzung des SRL-Poolkonzepts zwischen ÜNB und Anbietern [WWW] regelleistung.net. Available from: <https://www.regelleistung.net/ip/action/static/prequalSrl> [Accessed 22.03.2012].

FRAUNHOFER-INSTITUT FÜR KERAMISCHE TECHNOLOGIEN UND SYSTEME (IKTS) (Ed.) (2006) Intensivierung der Vergärung nachwachsender Rohstoffe durch mehrstufige Desintegration des anaeroben Fermenterinhalt – Laboruntersuchungen [WWW] Fraunhofer. Available from: <http://publica.fraunhofer.de/dokumente/N-65069.html> [Accessed 4/12/12].

GANAGIN, W. et al. (2011) Flexible Biogasproduktion zur Erzeugung von Spitzenlaststrom. In: *20. BIOGAS Jahrestagung Fachverband Biogas e.V.*, Nürnberg, 11.-13.01.2010. Freising: Fachverband Biogas e.V. pp. 157-167.

GE JENBACHER (Ed.) (2012) *Technische Beschreibung BHKW JMS 312 GS-B.L.* Jenbach: GE Jenbacher GmbH & Co OG.

GERHARDT, N. (2009) *Technische Potenziale einer variablen Stromeinspeisung durch Biogasanlagen* [WWW] Institut für Solare Energieversorgungstechnik (ISET). Available from: <http://renknownet.iset.uni-kassel.de/renknowNET/obj.download;jsessionid=7E95E0A8302D56B919E0D854B920037A?objName=694&lang=es> [Accessed: 14/06/2010].

GRANTNER, T. (n.d.) *Direktvermarktung Was bringt sie und was ist zu beachten?* [WWW] OMNICERT. Available from: <http://www.umweltgutachter.de/uploads/images/3IKIHryT-ket4dV4Wea2SXQ/eeg-2012-umweltgutachter-omnicert-biogas-direktvermarktung-flexibilitaetspraemiewasistzubeachten.pdf> [Accessed: 27.01.2015].

- GREEN GAS GRIDS (n.d) *Status quo of biomethane market* [WWW] German Energy Agency. Available from: <http://www.greengasgrids.eu/market-platform/cross-country-overview/status-quo-of-biomethane-market.html> [Accessed: 17/02/14].
- GRIM, J. (2015) Demand-Oriented Power Production from Biogas: Modeling and Simulations under Swedish Conditions. *energy & fuels*, 29 (7), pp. 4066-4075.
- GROSSMANN, J. et al. (2008) Zweistufige Trocken-Nass-Vergärung - Überführung vom Labor in die Praxis als GICON-Verfahren. *Internationales Fachsymposium Trockenfermentation*, Berlin, 21.-22. February. Kirchberg/Jagst: International Biogas and Bioenergy Centre of Competence (IBBK).
- HAHN, H. et al. (2014): Cost analysis of concepts for a demand oriented biogas supply for flexible power generation. *Bioresource Technology*, 170, pp. 211-220.
- HÄRING, G. et al. (2017) Demonstration of Controllable Electricity Production via Biogas Plants. In: *Chemical Engineering and Technology*, 40 (2), pp.298-305.
- HARTMANN, K. et al. (2010) *Endbericht - Die Rolle des Stromes aus Biogas in zukünftigen Energieversorgungsstrukturen*. Hanau: Fraunhofer-Institut für Windenergie und Energiesystemtechnik (IWES).
- HERDIN, G.R. (2002) *Standesanalyse des Gasmotors im Vergleich zu den Zukunftstechniken (Brennstoffzellen und Mikroturbine) bei der Nutzung von aus Biomasse gewonnenen Kraftstoffen* [WWW] Jenbacher AG. Available from: http://images.energieportal24.de/dateien/downloads/gasmotoren_analyse.pdf [Accessed: 06/02/12].
- HOLZHAMMER, U. NELLES and M. SCHOLWIN, F. (2013a) Auswirkung der flexiblen Stromproduktion aus Biogas auf den konventionellen Kraftwerkspark und dessen CO₂-Emissionen. *Optimierte Erfassung und Verwertung von Bioabfall*, Rostock, 7. Biomasse-Forum 2013, 21.-22. June 2013. Witzenhausen: Witzenhausen-Institut, pp. 145-167.
- HOLZHAMMER, U. et al. (2013b) Steuerbare Stromproduktion aus Biogas – Auswirkungen auf die Gasbereitstellung. In: 6. *Biogas-Innovationskongress*, Osnabrück, 23.-24. May 2013. Osnabrück: Deutsche Bundesstiftung Umwelt (DBU), pp. 117-131.
- HOLZHAMMER, U. LAVALL, D. and KRAUSE, T. (2013) Gasspeicher bedarfsgerecht dimensionieren. In: *BIOGAS Journal*, 3/2013, pp. 72-75.
- IEA (2014) *Statistics and Balances – Statistics by Country / Region* [WWW] International Energy Agency. Available from: <http://www.iea.org/stats/index.asp> [Accessed 15/02/14].

- JACOBI, H. TROMMLER M. and MAUKY, E. (2013): Bedarfsgerechte Biogasproduktion – Option für die Flexibilisierung erneuerbarer Energien. *ew – Magazin für die Energiewirtschaft*, 112 (1-2), pp. 22-25.
- KALTSCHMITT, M. HARTMANN, H. and HOFBAUER, H. (Eds.) (2009) *Energie aus Biomasse*. 2nd ed. Berlin/Heidelberg: Springer-Verlag.
- KEYMER, U. (2013) Direktvermarktung – Eine ökonomische Analyse für die Praxis. In: *Biogas in der Landwirtschaft – Stand und Perspektiven*, Kassel, 10.-11. September 2013. Darmstadt: Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL), pp. 46-59.
- KURATORIUM FÜR TECHNIK UND BAUWESEN IN DER LANDWIRTSCHAFT E.V. (KTBL) (ED.) (2009) *Faustzahlen Biogas*. 2nd ed. Darmstadt: Kuratorium für Technik und Bauwesen in der Landwirtschaft e.V. (KTBL).
- LUND, H. et al. (2012) From electricity smart grids to smart energy systems – A market operation based approach and understanding. *Energy*, 42 (1) pp. 96-102.
- JUNG, U. and MÜLLER, R. (2008) Teillast oder Takten?. *BWK Das Energie-Fachmagazin*, 6/2008. pp. 45-47.
- LIESNER, S. and GREWE, F. (2013) Mehrwert durch Repowering – was leistet ein BHKW der neuesten Generation. In: 22. *BIOGAS Jahrestagung Fachverband Biogas e.V., Leipzig*, 29.01.-31.01.2013. Freising: Fachverband Biogas e.V. pp. 11-18.
- NELLES, N. DANIEL-GROMKE, J. and DENYSENKO, V. (2013) Entwicklung der Biogaserzeugung in Deutschland *Biogas in der Landwirtschaft – Stand und Perspektiven*, Kassel, 10.-11. September 2013. Darmstadt: Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL), pp. 21-30.
- MÄHNERT, P. (2007) Kinetik der Biogasproduktion aus nachwachsenden Rohstoffen und Gülle. Dissertation (Dr. rer. agr.), Humboldt-Universität Berlin.
- MAUKY, E. et al. (2015) Flexible biogas production for demand-driven energy supply – Feeding strategies and types of substrates. *Bioresource Technology*, 178, pp. 262-269.
- MAUKY, E. et al. (2016) Model Predictive Control for Demand-Driven Biogas Production in Full Scale. *Chemical Engineering Technology*, 39 (4), pp. 652-664.

- MÜLLER, M. et al. (2011) Auswirkungen der flexiblen Fahrweise von Biogasanlagen zum Ausgleich von Nachfrageschwankungen. In: *20. BIOGAS Jahrestagung Fachverband Biogas e.V.*, Nürnberg, 11.-13.01.2011. Freising: Fachverband Biogas e.V. pp. 179-185.
- NITSCH, J. et al. (2009) *Leitstudie 2009 –Langfristszenarien und Strategien für den Ausbau erneuerbarer Energien in Deutschland unter Berücksichtigung der europäischen und globalen Entwicklung*. Berlin: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).
- NITSCH, J. et al. (2012) *Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global*, Schlussbericht BMU - FKZ 03MAP146. Berlin: German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).
- REGELLEISTUNG.NET (n.d.) *Gemeinsame Ausschreibung Sekundärregelleistung* [WWW] regelleistung.net. Available from: <https://www.regelleistung.net/ip/action/static/ausschreibungSrl> [Accessed: 21.03.12].
- ROHRIG, K. et al. (2011) Flexible Stromproduktion aus Biogas und Biomethan – Die Einführung einer Kapazitätskomponente als Förderinstrument [WWW] Fraunhofer-Institut für Windenergie und Energiesystemtechnik (IWES). Available from: http://www.iwes.fraunhofer.de/de/publikationen/uebersicht/2011/flexible_stromproduktionausbiogasundbiomethan/_jcr_content/pressrelease/linklistPar/download/file.res/Flexible%20Stromproduktion%20aus%20Biogas%20und%20Biomethan.pdf [Accessed: 30/11/2012].
- SCHMIDT, J. et al. (2009) Wissenschaftliche Begleitung bei der fachlichen Ausarbeitung eines Kombikraftwerksbonus gemäß der Verordnungsermächtigung § 64 EEG 2009 [WWW] German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). Available from: http://www.erneuerbare-energien.de/fileadmin/ee-import/files/pdfs/allgemein/application/pdf/abschlussbericht_kombikraftwerksbonus_bf.pdf [Accessed: 30/11/12].
- SACHVERSTÄNDIGENRAT FÜR UMWELTFRAGEN (Ed.) (2010) *100% erneuerbare Stromversorgung bis 2050: klimaverträglich, sicher, bezahlbar*. Berlin: Sachverständigenrat für Umweltfragen.
- SZARKA, N. et al. (2013) A novel role for bioenergy: A flexible, demand-oriented power supply. *Energy*, 61, pp. 18-26.

TENBRINK, J. (2013) Intelligente Steuerung der Regelenergie-BHKW-Leistung. In: 6. *Biogas-Innovationskongress*, Osnabrück, 23.-24. May 2013. Osnabrück: Deutsche Bundesstiftung Umwelt (DBU), pp. 141-147.

VAN BASSHUYSEN, R. and SCHÄFER, F. (2007) *Handbuch Verbrennungsmotor*. 4th ed. Wiesbaden: Vieweg Verlag.

VERBAND DER NETZBETREIBER VDN (2003) *Transmission Code 2003 Anhang D 1: Unterlagen zur Präqualifikation für die Erbringung von Primärregelleistung für die ÜNB* [WWW] Available from: <https://www.regelleistung.net/ip/action/static/prequal> [Accessed: 22.03.12].

VERBAND DER NETZBETREIBER (VDN) (Ed.) (2007a) *TransmissionCode 2007 Netz- und Systemregeln der deutschen Übertragungsnetzbetreiber* [WWW] [regelleistung.net](https://www.regelleistung.net). Available from: <https://www.regelleistung.net/ip/action/static/prequal> [Accessed: 22.03.2012].

VERBAND DER NETZBETREIBER (VDN) (Ed.) (2007b) *Transmission Code Anhang D 3: Unterlagen zur Präqualifikation für die Erbringung von Minutenreserveleistung* [WWW] [regelleistung.net](https://www.regelleistung.net) Available from: <https://www.regelleistung.net/ip/action/static/prequal> [Accessed 22.03.2012].

WORLD WILD FUND OF NATURE (WWF) (Ed.) (2009) *Modell Deutschland. Klimaschutz bis 2050: Vom Ziel her denken*. Basel/Berlin: WWF.

WELLINGER, A. LITMANEN, S. and PRAZDKA, A. (2013) Biogas im europäischen Kontext. In *Biogas in der Landwirtschaft – Stand und Perspektiven*, Kassel, 10.-11. September 2013. Darmstadt: Kuratorium für Technik und Bauwesen in der Landwirtschaft (KTBL), pp. 11-20.

ZACHARIAS, F. (2001) *Gasmotoren*. Würzburg: Vogel Verlag und Druck GmbH&Co. KG.

ZÖRNER, W. et al. (2010) *Handreichung zur Optimierung von Biogasanlagen*. Ingolstadt: Hochschule Ingolstadt.

2G ENERGIE TECHNIK (Ed.) (2011) *Planungsdaten 2G-KWK-190BG/50 Hz*. Version 1.3, Heek: 2G Energietechnik GmbH.

Appendix A: Parameter Study

A.1 $P_{\text{rated}} = 250 \text{ kW}_{\text{el}}$

Variant 1.25-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	313		
Padditional [kWel]	38		
CHP 1 [kWel]	250	6,935	1,733,750
CHP 2 (additional CHP) [kWel]	63	7,300	456,250
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	112,920.22	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	5,312.50	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	5,000.00	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63
Investment Total without Interest	137,232.72										
Sum	152,776.42	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		50.00	51.00	52.02	53.06	54.12	55.20	56.31	57.43	58.58	59.75
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	58,001.24	5,297.05	5,402.99	5,511.05	5,621.27	5,733.70	5,848.37	5,965.34	6,084.65	6,206.34	6,330.47
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	8,364.30	763.88	779.16	794.74	810.64	826.85	843.39	860.26	877.46	895.01	912.91
Other Costs Total without Interest	59,364.30										
Sum	65,140.83	6,441.54	6,456.81	6,472.40	6,488.29	6,504.50	6,521.04	6,537.91	6,555.11	6,572.66	6,590.56
Costs	318,408.11	30,896.66	31,095.49	31,298.29	31,505.15	31,716.15	31,931.36	32,150.89	32,374.80	32,603.19	32,836.14
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	44,665.90	4,875.00	4,779.41	4,685.70	4,593.82	4,503.75	4,415.44	4,328.86	4,243.98	4,160.77	4,079.18
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	60,192.61	5,497.18	5,607.13	5,719.27	5,833.65	5,950.33	6,069.33	6,190.72	6,314.53	6,440.83	6,569.64
Sum	144,989.11	14,752.18	14,680.66	14,614.89	14,554.85	14,500.52	14,451.87	14,408.90	14,371.57	14,339.88	14,313.81
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-16,144.48	-16,414.83	-16,683.40	-16,950.30	-17,215.63	-17,479.49	-17,741.99	-18,003.23	-18,263.31	-18,522.33	-18,782.33
Return on Investment		-7%	-8%	-8%	-8%	-8%	-8%	-8%	-8%	-8%	-8%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.014	0.014	0.014	0.014	0.014	0.015	0.015	0.015	0.015	0.015

Variant 1.25-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	313		
Padditional [kWel]	38		
CHP 1 [kWel]	250	7,094	1,773,500
CHP 2 (additional CHP) [kWel]	63	6,675	417,188
Total Electricity Production [kWhel/a]	2,190,688		
Additional Earnings Electricity Market [€/kWel; rated a]	23.85		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	112,920.22	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	5,312.50	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	5,000.00	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63
Investment Total without Interest	137,232.72										
Sum	152,776.42	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.54	1,573.39	1,604.85	1,636.95	1,669.69	1,703.08	1,737.15	1,771.89	1,807.33	1,843.47
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		53.13	54.19	55.27	56.38	57.50	58.65	59.83	61.02	62.24	63.49
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		50.00	51.00	52.02	53.06	54.12	55.20	56.31	57.43	58.58	59.75
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	58,588.24	5,350.66	5,457.67	5,566.83	5,678.16	5,791.73	5,907.56	6,025.71	6,146.23	6,269.15	6,394.53
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	8,364.30	763.88	779.16	794.74	810.64	826.85	843.39	860.26	877.46	895.01	912.91
Other Costs Total without Interest	59,364.30										
Sum	65,140.83	6,441.54	6,456.81	6,472.40	6,488.29	6,504.50	6,521.04	6,537.91	6,555.11	6,572.66	6,590.56
Costs	318,995.11	30,950.27	31,150.17	31,354.06	31,562.04	31,774.18	31,990.55	32,211.26	32,436.38	32,666.00	32,900.21
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	44,679.93	4,876.53	4,780.91	4,687.17	4,595.26	4,505.16	4,416.82	4,330.22	4,245.31	4,162.07	4,080.46
Application Value 0,002 €/kWh	40,143.19	4,381.38	4,295.47	4,211.24	4,128.67	4,047.71	3,968.35	3,890.54	3,814.25	3,739.46	3,666.14
Additional Market Profits	65,280.29	5,961.82	6,081.06	6,202.68	6,326.73	6,453.27	6,582.33	6,713.98	6,848.26	6,985.23	7,124.93
Sum	150,103.41	15,219.73	15,157.44	15,101.09	15,050.66	15,006.14	14,967.50	14,934.74	14,907.82	14,886.76	14,871.53
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-15,730.54	-15,992.73	-16,252.98	-16,511.38	-16,768.03	-17,023.05	-17,276.52	-17,528.55	-17,779.24	-18,028.68
Return on Investment		-7%	-7%	-7%	-8%	-8%	-8%	-8%	-8%	-8%	-8%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.014	0.014	0.014	0.014	0.015	0.015	0.015	0.015	0.015	0.015

Appendix

Variant 1.25-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	313		
Padditional [kWel]	38		
CHP 1 [kWel]	250	7,070	1,767,500
CHP 2 (additional CHP) [kWel]	63	6,760	422,500
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	26.24		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	112,920.22	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	5,312.50	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	5,000.00	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63
Investment Total without Interest	137,232.72										
Sum	152,776.42	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64	15,277.64
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		53.13	54.19	55.27	56.38	57.50	58.65	59.83	61.02	62.24	63.49
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		50.00	51.00	52.02	53.06	54.12	55.20	56.31	57.43	58.58	59.75
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	58,582.94	5,350.18	5,457.18	5,566.32	5,677.65	5,791.20	5,907.03	6,025.17	6,145.67	6,268.58	6,393.96
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	8,364.30	763.88	779.16	794.74	810.64	826.85	843.39	860.26	877.46	895.01	912.91
Other Costs Total without Interest	59,364.30										
Sum	65,140.83	6,441.54	6,456.81	6,472.40	6,488.29	6,504.50	6,521.04	6,537.91	6,555.11	6,572.66	6,590.56
Costs											
	318,989.81	30,949.78	31,149.67	31,353.56	31,561.53	31,773.65	31,990.02	32,210.71	32,435.82	32,665.43	32,899.63
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	44,665.90	4,875.00	4,779.41	4,685.70	4,593.82	4,503.75	4,415.44	4,328.86	4,243.98	4,160.77	4,079.18
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	71,829.51	6,559.94	6,691.14	6,824.96	6,961.46	7,100.69	7,242.70	7,387.56	7,535.31	7,686.02	7,839.74
Sum	156,626.01	15,814.94	15,764.67	15,720.58	15,682.65	15,650.88	15,625.24	15,605.73	15,592.34	15,585.07	15,583.91
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-15,134.84	-15,385.01	-15,632.98	-15,878.87	-16,122.77	-16,364.78	-16,604.98	-16,843.48	-17,080.36	-17,315.73
Return on Investment		-7%	-7%	-7%	-7%	-7%	-8%	-8%	-8%	-8%	-8%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.014	0.014	0.014	0.014	0.015	0.015	0.015	0.015	0.015	0.015

Variant 1.25-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	313		
Padditional [kWel]	38		
CHP 1 [kWel]	250	6,935	1,733,750
CHP 2 (additional CHP) [kWel]	63	7,300	456,250
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	112,920.22	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	5,312.50	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	5,000.00	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63
Investment Total without Interest	199,686.61										
Sum	222,304.17	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		53.13	54.19	55.27	56.38	57.50	58.65	59.83	61.02	62.24	63.49
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		50.00	51.00	52.02	53.06	54.12	55.20	56.31	57.43	58.58	59.75
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	79,098.52	7,223.79	7,368.27	7,515.63	7,665.95	7,819.27	7,975.65	8,135.16	8,297.87	8,463.82	8,633.10
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	12,170.84	1,111.52	1,133.75	1,156.43	1,179.55	1,203.15	1,227.21	1,251.75	1,276.79	1,302.32	1,328.37
Other Costs Total without Interest	63,170.84										
Sum	68,947.37	6,789.17	6,811.40	6,834.08	6,857.21	6,880.80	6,904.86	6,929.41	6,954.44	6,979.98	7,006.02
Costs	412,839.68	40,123.81	40,368.13	40,617.33	40,871.51	41,130.78	41,395.24	41,664.98	41,940.12	42,220.76	42,507.01
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	44,665.90	4,875.00	4,779.41	4,685.70	4,593.82	4,503.75	4,415.44	4,328.86	4,243.98	4,160.77	4,079.18
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	60,192.61	5,497.18	5,607.13	5,719.27	5,833.65	5,950.33	6,069.33	6,190.72	6,314.53	6,440.83	6,569.64
Sum	144,989.11	14,752.18	14,680.66	14,614.89	14,554.85	14,500.52	14,451.87	14,408.90	14,371.57	14,339.88	14,313.81
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-25,371.63	-25,687.47	-26,002.44	-26,316.67	-26,630.27	-26,943.37	-27,256.09	-27,568.55	-27,880.88	-28,193.20
Return on Investment		-9%	-9%	-9%	-9%	-9%	-9%	-9%	-9%	-10%	-10%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019

Appendix

Variant 1.25-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	313		
Padditional [kWel]	38		
CHP 1 [kWel]	250	7,093	1,773,250
CHP 2 (additional CHP) [kWel]	63	6,675	417,188
Total Electricity Production [kWhel/a]	2,190,438		
Additional Earnings Electricity Market [€/kWel; rated a]	26.55		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	112,920.22	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	5,312.50	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	5,000.00	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63
Investment Total without Interest	199,686.61										
Sum	222,304.17	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.36	1,573.21	1,604.67	1,636.76	1,669.50	1,702.89	1,736.95	1,771.69	1,807.12	1,843.26
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		53.13	54.19	55.27	56.38	57.50	58.65	59.83	61.02	62.24	63.49
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		50.00	51.00	52.02	53.06	54.12	55.20	56.31	57.43	58.58	59.75
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	79,101.89	7,224.10	7,368.58	7,515.95	7,666.27	7,819.60	7,975.99	8,135.51	8,298.22	8,464.19	8,633.47
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	12,170.84	1,111.52	1,133.75	1,156.43	1,179.55	1,203.15	1,227.21	1,251.75	1,276.79	1,302.32	1,328.37
Other Costs Total without Interest	63,170.84										
Sum	68,947.37	6,789.17	6,811.40	6,834.08	6,857.21	6,880.80	6,904.86	6,929.41	6,954.44	6,979.98	7,006.02
Costs	412,843.05	40,124.12	40,368.44	40,617.65	40,871.84	41,131.12	41,395.58	41,665.33	41,940.47	42,221.12	42,507.38
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	44,674.83	4,875.97	4,780.37	4,686.63	4,594.74	4,504.65	4,416.32	4,329.73	4,244.83	4,161.60	4,080.00
Application Value 0,002 €/kWh	40,138.61	4,380.88	4,294.98	4,210.76	4,128.20	4,047.25	3,967.89	3,890.09	3,813.82	3,739.03	3,665.72
Additional Market Profits	72,691.95	6,638.70	6,771.48	6,906.91	7,045.05	7,185.95	7,329.67	7,476.26	7,625.78	7,778.30	7,933.87
Sum	157,505.39	15,895.55	15,846.82	15,804.30	15,767.98	15,737.84	15,713.88	15,696.08	15,684.43	15,678.93	15,679.58
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-24,228.57	-24,521.62	-24,813.35	-25,103.86	-25,393.27	-25,681.70	-25,969.25	-26,256.05	-26,542.19	-26,827.80	-27,113.41
Return on Investment		-8%	-8%	-9%	-9%	-9%	-9%	-9%	-9%	-9%	-9%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019

Variant 1.25-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	313		
Padditional [kWel]	38		
CHP 1 [kWel]	250	7,045	1,761,250
CHP 2 (additional CHP) [kWel]	63	6,860	428,750
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	30.23		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	112,920.22	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	5,312.50	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	5,000.00	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63
Investment Total without Interest	199,686.61										
Sum	222,304.17	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42	22,230.42
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		53.13	54.19	55.27	56.38	57.50	58.65	59.83	61.02	62.24	63.49
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		50.00	51.00	52.02	53.06	54.12	55.20	56.31	57.43	58.58	59.75
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	79,098.52	7,223.79	7,368.27	7,515.63	7,665.95	7,819.27	7,975.65	8,135.16	8,297.87	8,463.82	8,633.10
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	12,170.84	1,111.52	1,133.75	1,156.43	1,179.55	1,203.15	1,227.21	1,251.75	1,276.79	1,302.32	1,328.37
Other Costs Total without Interest	63,170.84										
Sum	68,947.37	6,789.17	6,811.40	6,834.08	6,857.21	6,880.80	6,904.86	6,929.41	6,954.44	6,979.98	7,006.02
Costs	412,839.68	40,123.81	40,368.13	40,617.33	40,871.51	41,130.78	41,395.24	41,664.98	41,940.12	42,220.76	42,507.01
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	44,665.90	4,875.00	4,779.41	4,685.70	4,593.82	4,503.75	4,415.44	4,328.86	4,243.98	4,160.77	4,079.18
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	82,751.72	7,557.43	7,708.58	7,862.75	8,020.00	8,180.40	8,344.01	8,510.89	8,681.11	8,854.73	9,031.82
Sum	167,548.22	16,812.43	16,782.10	16,758.36	16,741.20	16,730.59	16,726.55	16,729.07	16,738.14	16,753.78	16,775.99
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-23,311.39	-23,586.02	-23,858.97	-24,130.32	-24,400.19	-24,668.69	-24,935.92	-25,201.98	-25,466.98	-25,731.02
Return on Investment		-8%	-8%	-8%	-8%	-8%	-8%	-8%	-9%	-9%	-9%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019

Appendix

Variant 1.25-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	313		
Padditional [kWel]	38		
CHP 1 [kWel]	250	6,935	1,733,750
CHP 2 (additional CHP) [kWel]	63	7,300	456,250
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	112,920.22	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	5,312.50	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	5,000.00	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63
<i>Investment Total without Interest</i>	226,584.05										
Sum	252,248.15	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		53.13	54.19	55.27	56.38	57.50	58.65	59.83	61.02	62.24	63.49
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		50.00	51.00	52.02	53.06	54.12	55.20	56.31	57.43	58.58	59.75
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	87,934.10	8,030.72	8,191.33	8,355.16	8,522.26	8,692.71	8,866.56	9,043.89	9,224.77	9,409.26	9,597.45
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	13,810.23	1,261.24	1,286.47	1,312.19	1,338.44	1,365.21	1,392.51	1,420.36	1,448.77	1,477.74	1,507.30
<i>Other Costs Total without Interest</i>	64,810.23										
Sum	70,586.76	6,938.89	6,964.12	6,989.85	7,016.09	7,042.86	7,070.16	7,098.01	7,126.42	7,155.40	7,184.95
Costs	453,258.64	44,074.85	44,338.30	44,607.02	44,881.11	45,160.68	45,445.85	45,736.71	46,033.40	46,336.02	46,644.69
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	44,665.90	4,875.00	4,779.41	4,685.70	4,593.82	4,503.75	4,415.44	4,328.86	4,243.98	4,160.77	4,079.18
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	60,192.61	5,497.18	5,607.13	5,719.27	5,833.65	5,950.33	6,069.33	6,190.72	6,314.53	6,440.83	6,569.64
Sum	144,989.11	14,752.18	14,680.66	14,614.89	14,554.85	14,500.52	14,451.87	14,408.90	14,371.57	14,339.88	14,313.81
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-29,322.67	-29,657.65	-29,992.13	-30,326.26	-30,660.17	-30,993.98	-31,327.82	-31,661.83	-31,996.14	-32,330.88	-32,665.69
Return on Investment		-9%	-9%	-9%	-9%	-9%	-10%	-10%	-10%	-10%	-10%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.020	0.020	0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021

Variant 1.25-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	313		
Padditional [kWel]	38		
CHP 1 [kWel]	250	7,093	1,773,250
CHP 2 (additional CHP) [kWel]	63	6,675	417,188
Total Electricity Production [kWhel/a]	2,190,438		
Additional Earnings Electricity Market [€/kWel; rated a]	28.02		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	112,920.22	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	5,312.50	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	5,000.00	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63
Investment Total without Interest	226,584.05										
Sum	252,248.15	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.36	1,573.21	1,604.67	1,636.76	1,669.50	1,702.89	1,736.95	1,771.69	1,807.12	1,843.26
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		53.13	54.19	55.27	56.38	57.50	58.65	59.83	61.02	62.24	63.49
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		50.00	51.00	52.02	53.06	54.12	55.20	56.31	57.43	58.58	59.75
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	87,937.47	8,031.02	8,191.64	8,355.48	8,522.59	8,693.04	8,866.90	9,044.24	9,225.12	9,409.62	9,597.82
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	13,810.23	1,261.24	1,286.47	1,312.19	1,338.44	1,365.21	1,392.51	1,420.36	1,448.77	1,477.74	1,507.30
Other Costs Total without Interest	64,810.23										
Sum	70,586.76	6,938.89	6,964.12	6,989.85	7,016.09	7,042.86	7,070.16	7,098.01	7,126.42	7,155.40	7,184.95
Costs	453,262.01	44,075.16	44,338.62	44,607.34	44,881.44	45,161.02	45,446.19	45,737.06	46,033.75	46,336.38	46,645.06
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	44,674.83	4,875.97	4,780.37	4,686.63	4,594.74	4,504.65	4,416.32	4,329.73	4,244.83	4,161.60	4,080.00
Application Value 0,002 €/kWh	40,138.61	4,380.88	4,294.98	4,210.76	4,128.20	4,047.25	3,967.89	3,890.09	3,813.82	3,739.03	3,665.72
Additional Market Profits	76,706.45	7,005.33	7,145.44	7,288.35	7,434.12	7,582.80	7,734.45	7,889.14	8,046.93	8,207.87	8,372.02
Sum	161,519.90	16,262.18	16,220.78	16,185.74	16,157.05	16,134.70	16,118.67	16,108.96	16,105.57	16,108.50	16,117.74
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-27,812.98	-28,117.83	-28,421.60	-28,724.38	-29,026.32	-29,327.52	-29,628.10	-29,928.18	-30,227.88	-30,527.32
Return on Investment		-9%	-9%	-9%	-9%	-9%	-9%	-9%	-9%	-9%	-9%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.020	0.020	0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021

Appendix

Variant 1.25-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	313		
Padditional [kWel]	38		
CHP 1 [kWel]	250	7,012	1,753,000
CHP 2 (additional CHP) [kWel]	63	6,992	437,000
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	33.35		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	112,920.22	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02	12,571.02
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	5,312.50	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42	591.42
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	5,000.00	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63	556.63
<i>Investment Total without Interest</i>	226,584.05										
Sum	252,248.15	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82	25,224.82
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		53.13	54.19	55.27	56.38	57.50	58.65	59.83	61.02	62.24	63.49
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		50.00	51.00	52.02	53.06	54.12	55.20	56.31	57.43	58.58	59.75
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	87,934.10	8,030.72	8,191.33	8,355.16	8,522.26	8,692.71	8,866.56	9,043.89	9,224.77	9,409.26	9,597.45
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	13,810.23	1,261.24	1,286.47	1,312.19	1,338.44	1,365.21	1,392.51	1,420.36	1,448.77	1,477.74	1,507.30
<i>Other Costs Total without Interest</i>	64,810.23										
Sum	70,586.76	6,938.89	6,964.12	6,989.85	7,016.09	7,042.86	7,070.16	7,098.01	7,126.42	7,155.40	7,184.95
Costs	453,258.64	44,074.85	44,338.30	44,607.02	44,881.11	45,160.68	45,445.85	45,736.71	46,033.40	46,336.02	46,644.69
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	44,665.90	4,875.00	4,779.41	4,685.70	4,593.82	4,503.75	4,415.44	4,328.86	4,243.98	4,160.77	4,079.18
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	91,306.97	8,338.75	8,505.52	8,675.63	8,849.15	9,026.13	9,206.65	9,390.78	9,578.60	9,770.17	9,965.58
Sum	176,103.47	17,593.75	17,579.05	17,571.25	17,570.34	17,576.32	17,589.19	17,608.96	17,635.63	17,669.23	17,709.75
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-26,481.11	-26,759.25	-27,035.77	-27,310.77	-27,584.36	-27,856.66	-28,127.75	-28,397.76	-28,666.79	-28,934.94
Return on Investment		-8%	-8%	-8%	-8%	-9%	-9%	-9%	-9%	-9%	-9%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.020	0.020	0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021

Variant 1.5-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	375		
Padditional [kWel]	100		
CHP 1 [kWel]	250	6,205	1,551,250
CHP 2 (additional CHP) [kWel]	125	5,110	638,750
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	32.18		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	180,288.06	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	10,625.00	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Investment Total without Interest	214,913.06										
Sum	239,255.25	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		106.25	108.38	110.54	112.75	115.01	117.31	119.65	122.05	124.49	126.98
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		100.00	102.00	104.04	106.12	108.24	110.41	112.62	114.87	117.17	119.51
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	59,712.13	5,453.30	5,562.37	5,673.61	5,787.09	5,902.83	6,020.89	6,141.30	6,264.13	6,389.41	6,517.20
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	13,098.89	1,196.28	1,220.20	1,244.61	1,269.50	1,294.89	1,320.79	1,347.20	1,374.15	1,401.63	1,429.66
Other Costs Total without Interest	64,098.89										
Sum	69,875.42	6,873.93	6,897.85	6,922.26	6,947.15	6,972.54	6,998.44	7,024.85	7,051.80	7,079.28	7,107.31
Costs	411,332.42	40,133.19	40,343.79	40,558.60	40,777.71	41,001.20	41,229.16	41,461.68	41,698.85	41,940.76	42,187.51
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	119,109.08	13,000.00	12,745.10	12,495.19	12,250.19	12,009.99	11,774.50	11,543.63	11,317.28	11,095.37	10,877.82
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	88,087.54	8,044.73	8,205.62	8,369.74	8,537.13	8,707.87	8,882.03	9,059.67	9,240.86	9,425.68	9,614.20
Sum	247,327.21	25,424.73	25,244.84	25,074.85	24,914.69	24,764.31	24,623.63	24,492.61	24,371.20	24,259.34	24,157.00
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-14,708.46	-15,098.95	-15,483.75	-15,863.01	-16,236.89	-16,605.52	-16,969.06	-17,327.65	-17,681.42	-18,030.51
Return on Investment		-5%	-5%	-5%	-5%	-5%	-5%	-5%	-6%	-6%	-6%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019

Appendix

Variant 1.5-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	375		
Padditional [kWel]	100		
CHP 1 [kWel]	250	6,101	1,525,179
CHP 2 (additional CHP) [kWel]	125	5,319	664,821
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	35.06		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10	
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	
Additional CHP	180,288.06	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	
Gas Conditioning / Gas Pipe System	10,625.00	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	
Transformer / Grid	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	
Investment Total without Interest	214,913.06											
Sum	239,255.25	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19	
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28	
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47	
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89	
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53	
Gas Conditioning / Gas Pipe System		106.25	108.38	110.54	112.75	115.01	117.31	119.65	122.05	124.49	126.98	
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41	
Transformer / Grid		100.00	102.00	104.04	106.12	108.24	110.41	112.62	114.87	117.17	119.51	
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88	
Sum	59,712.13	5,453.30	5,562.37	5,673.61	5,787.09	5,902.83	6,020.89	6,141.30	6,264.13	6,389.41	6,517.20	
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	
Insurance	13,098.89	1,196.28	1,220.20	1,244.61	1,269.50	1,294.89	1,320.79	1,347.20	1,374.15	1,401.63	1,429.66	
Other Costs Total without Interest	64,098.89											
Sum	69,875.42	6,873.93	6,897.85	6,922.26	6,947.15	6,972.54	6,998.44	7,024.85	7,051.80	7,079.28	7,107.31	
Costs		411,332.42	40,133.19	40,343.79	40,558.60	40,777.71	41,001.20	41,229.16	41,461.68	41,698.85	41,940.76	42,187.51
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	
Flexible Premium	119,109.07	13,000.00	12,745.10	12,495.19	12,250.19	12,009.99	11,774.50	11,543.63	11,317.28	11,095.37	10,877.82	
Application Value 0,002 €/kWh	40,130.59	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99	
Additional Market Profits	95,982.55	8,765.75	8,941.07	9,119.89	9,302.29	9,488.33	9,678.10	9,871.66	10,069.09	10,270.48	10,475.89	
Sum	255,222.21	26,145.75	25,980.28	25,825.00	25,679.85	25,544.76	25,419.70	25,304.60	25,199.43	25,104.14	25,018.69	
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	
Sum		-13,987.43	-14,363.50	-14,733.60	-15,097.86	-15,456.43	-15,809.46	-16,157.07	-16,499.42	-16,836.62	-17,168.82	
Return on Investment		-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-6%	
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	

Variant 1.5-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	375		
Padditional [kWel]	100		
CHP 1 [kWel]	250	6,085	1,521,250
CHP 2 (additional CHP) [kWel]	125	5,350	668,750
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	38.25		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	180,288.06	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Füllstandsüberwachung weiterer Behälter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Conditioning / Gas Pipe System	10,625.00	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
<i>Investment Total without Interest</i>	214,913.06										
Sum	239,255.25	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52	23,925.52
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]	300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53	365.71
Gas Conditioning / Gas Pipe System		106.25	108.38	110.54	112.75	115.01	117.31	119.65	122.05	124.49	126.98
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		100.00	102.00	104.04	106.12	108.24	110.41	112.62	114.87	117.17	119.51
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	59,712.13	5,453.30	5,562.37	5,673.61	5,787.09	5,902.83	6,020.89	6,141.30	6,264.13	6,389.41	6,517.20
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	13,098.89	1,196.28	1,220.20	1,244.61	1,269.50	1,294.89	1,320.79	1,347.20	1,374.15	1,401.63	1,429.66
<i>Other Costs Total without Interest</i>	64,098.89										
Sum	69,875.42	6,873.93	6,897.85	6,922.26	6,947.15	6,972.54	6,998.44	7,024.85	7,051.80	7,079.28	7,107.31
Costs	411,332.42	40,133.19	40,343.79	40,558.60	40,777.71	41,001.20	41,229.16	41,461.68	41,698.85	41,940.76	42,187.51
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	119,109.08	13,000.00	12,745.10	12,495.19	12,250.19	12,009.99	11,774.50	11,543.63	11,317.28	11,095.37	10,877.82
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	104,706.71	9,562.50	9,753.75	9,948.83	10,147.80	10,350.76	10,557.77	10,768.93	10,984.31	11,203.99	11,428.07
Sum	263,946.38	26,942.50	26,792.97	26,653.94	26,525.36	26,407.19	26,299.37	26,201.87	26,114.64	26,037.66	25,970.88
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-13,190.69	-13,550.82	-13,904.66	-14,252.34	-14,594.01	-14,929.78	-15,259.81	-15,584.20	-15,903.10	-16,216.63	-16,526.63
Return on Investment		-4%	-4%	-4%	-5%	-5%	-5%	-5%	-5%	-5%	-5%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019

Appendix

Variant 1.5-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	375		
Padditional [kWel]	100		
CHP 1 [kWel]	250	5,840	1,460,000
CHP 2 (additional CHP) [kWel]	125	5,475	684,375
Total Electricity Production [kWhel/a]	2,144,375		
Additional Earnings Electricity Market [€/kWel; rated a]	32.53		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	180,288.06	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	10,625.00	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Investment Total without Interest	277,366.95										
Sum	308,782.99	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,509.93	1,540.12	1,570.93	1,602.34	1,634.39	1,667.08	1,700.42	1,734.43	1,769.12	1,804.50
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		106.25	108.38	110.54	112.75	115.01	117.31	119.65	122.05	124.49	126.98
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		100.00	102.00	104.04	106.12	108.24	110.41	112.62	114.87	117.17	119.51
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	79,875.94	7,294.79	7,440.69	7,589.50	7,741.29	7,896.12	8,054.04	8,215.12	8,379.42	8,547.01	8,717.95
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	16,905.44	1,543.91	1,574.79	1,606.29	1,638.41	1,671.18	1,704.61	1,738.70	1,773.47	1,808.94	1,845.12
Other Costs Total without Interest	67,905.44										
Sum	73,681.97	7,221.57	7,252.45	7,283.94	7,316.07	7,348.84	7,382.26	7,416.35	7,451.13	7,486.60	7,522.77
Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
	504,830.52	49,275.09	49,529.47	49,788.94	50,053.60	50,323.55	50,598.91	50,879.77	51,166.24	51,458.45	51,756.50
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	116,627.64	12,729.17	12,479.58	12,234.88	11,994.98	11,759.78	11,529.20	11,303.14	11,081.51	10,864.22	10,651.20
Application Value 0,002 €/kWh	39,294.54	4,288.75	4,204.66	4,122.21	4,041.38	3,962.14	3,884.45	3,808.29	3,733.61	3,660.41	3,588.63
Additional Market Profits	89,044.69	8,132.14	8,294.79	8,460.68	8,629.90	8,802.49	8,978.54	9,158.11	9,341.28	9,528.10	9,718.66
Sum	244,966.88	25,150.06	24,979.02	24,817.77	24,666.26	24,524.42	24,392.19	24,269.54	24,156.40	24,052.73	23,958.49
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-24,125.03	-24,550.45	-24,971.17	-25,387.34	-25,799.14	-26,206.71	-26,610.23	-27,009.85	-27,405.72	-27,798.00
Return on Investment		-6%	-6%	-7%	-7%	-7%	-7%	-7%	-7%	-7%	-7%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.023	0.023	0.023	0.023	0.023	0.024	0.024	0.024	0.024	0.024

Variant 1.5-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	375		
Padditional [kWel]	100		
CHP 1 [kWel]	250	5,892	1,473,035
CHP 2 (additional CHP) [kWel]	125	5,736	716,964
Total Electricity Production [kWhel/a]	2,189,999		
Additional Earnings Electricity Market [€/kWel; rated a]	41.68		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	180,288.06	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	10,625.00	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Investment Total without Interest	277,366.95										
Sum	308,782.99	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		106.25	108.38	110.54	112.75	115.01	117.31	119.65	122.05	124.49	126.98
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		100.00	102.00	104.04	106.12	108.24	110.41	112.62	114.87	117.17	119.51
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	80,227.70	7,326.92	7,473.46	7,622.92	7,775.38	7,930.89	8,089.51	8,251.30	8,416.32	8,584.65	8,756.34
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	16,905.44	1,543.91	1,574.79	1,606.29	1,638.41	1,671.18	1,704.61	1,738.70	1,773.47	1,808.94	1,845.12
Other Costs Total without Interest	67,905.44										
Sum	73,681.97	7,221.57	7,252.45	7,283.94	7,316.07	7,348.84	7,382.26	7,416.35	7,451.13	7,486.60	7,522.77
Costs	505,182.28	49,307.21	49,562.24	49,822.36	50,087.69	50,358.33	50,634.38	50,915.94	51,203.14	51,496.09	51,794.89
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	119,109.01	12,999.99	12,745.09	12,495.19	12,250.18	12,009.98	11,774.49	11,543.62	11,317.28	11,095.37	10,877.81
Application Value 0,002 €/kWh	40,130.57	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	114,103.05	10,420.64	10,629.05	10,841.63	11,058.46	11,279.63	11,505.22	11,735.33	11,970.03	12,209.44	12,453.62
Sum	273,342.63	27,800.63	27,668.25	27,546.73	27,436.01	27,336.06	27,246.82	27,168.26	27,100.36	27,043.09	26,996.42
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-21,506.59	-21,893.99	-22,275.63	-22,651.68	-23,022.27	-23,387.56	-23,747.68	-24,102.78	-24,453.00	-24,798.47
Return on Investment		-6%	-6%	-6%	-6%	-6%	-6%	-6%	-6%	-6%	-6%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.024	0.024

Appendix

Variant 1.5-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	375		
Padditional [kWel]	100		
CHP 1 [kWel]	250	5,890	1,472,500
CHP 2 (additional CHP) [kWel]	125	5,740	717,500
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	45,90		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	180,288.06	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	10,625.00	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
<i>Investment Total without Interest</i>	277,366.95										
Sum	308,782.99	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30	30,878.30
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		106.25	108.38	110.54	112.75	115.01	117.31	119.65	122.05	124.49	126.98
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		100.00	102.00	104.04	106.12	108.24	110.41	112.62	114.87	117.17	119.51
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	80,227.71	7,326.92	7,473.46	7,622.93	7,775.38	7,930.89	8,089.51	8,251.30	8,416.33	8,584.65	8,756.35
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	16,905.44	1,543.91	1,574.79	1,606.29	1,638.41	1,671.18	1,704.61	1,738.70	1,773.47	1,808.94	1,845.12
<i>Other Costs Total without Interest</i>	67,905.44										
Sum	73,681.97	7,221.57	7,252.45	7,283.94	7,316.07	7,348.84	7,382.26	7,416.35	7,451.13	7,486.60	7,522.77
Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
	505,182.29	49,307.21	49,562.24	49,822.37	50,087.69	50,358.33	50,634.38	50,915.95	51,203.14	51,496.09	51,794.89
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	119,109.08	13,000.00	12,745.10	12,495.19	12,250.19	12,009.99	11,774.50	11,543.63	11,317.28	11,095.37	10,877.82
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	125,642.77	11,474.52	11,704.01	11,938.09	12,176.85	12,420.39	12,668.79	12,922.17	13,180.61	13,444.23	13,713.11
Sum	284,882.44	28,854.52	28,743.22	28,643.20	28,554.41	28,476.82	28,410.40	28,355.11	28,310.95	28,277.89	28,255.92
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-20,452.70	-20,819.02	-21,179.16	-21,533.28	-21,881.51	-22,223.98	-22,560.83	-22,892.20	-23,218.20	-23,538.97
Return on Investment		-5%	-5%	-6%	-6%	-6%	-6%	-6%	-6%	-6%	-6%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.024	0.024

Variant 1.5-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	375		
Padditional [kWel]	100		
CHP 1 [kWel]	250	5,840	1,460,000
CHP 2 (additional CHP) [kWel]	125	5,475	684,375
Total Electricity Production [kWhel/a]	2,144,375		
Additional Earnings Electricity Market [€/kWel; rated a]	32.53		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	180,288.06	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	10,625.00	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Investment Total without Interest	304,264.39										
Sum	338,726.98	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,509.93	1,540.12	1,570.93	1,602.34	1,634.39	1,667.08	1,700.42	1,734.43	1,769.12	1,804.50
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		106.25	108.38	110.54	112.75	115.01	117.31	119.65	122.05	124.49	126.98
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		100.00	102.00	104.04	106.12	108.24	110.41	112.62	114.87	117.17	119.51
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	88,711.52	8,101.72	8,263.75	8,429.02	8,597.60	8,769.56	8,944.95	9,123.85	9,306.32	9,492.45	9,682.30
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	18,544.83	1,693.63	1,727.51	1,762.06	1,797.30	1,833.24	1,869.91	1,907.31	1,945.45	1,984.36	2,024.05
Other Costs Total without Interest	69,544.83										
Sum	75,321.36	7,371.29	7,405.16	7,439.71	7,474.95	7,510.90	7,547.56	7,584.96	7,623.11	7,662.02	7,701.70
Costs	545,249.48	53,226.13	53,499.65	53,778.63	54,063.20	54,353.45	54,649.52	54,951.50	55,259.52	55,573.71	55,894.17
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	116,627.64	12,729.17	12,479.58	12,234.88	11,994.98	11,759.78	11,529.20	11,303.14	11,081.51	10,864.22	10,651.20
Application Value 0,002 €/kWh	39,294.54	4,288.75	4,204.66	4,122.21	4,041.38	3,962.14	3,884.45	3,808.29	3,733.61	3,660.41	3,588.63
Additional Market Profits	89,044.69	8,132.14	8,294.79	8,460.68	8,629.90	8,802.49	8,978.54	9,158.11	9,341.28	9,528.10	9,718.66
Sum	244,966.88	25,150.06	24,979.02	24,817.77	24,666.26	24,524.42	24,392.19	24,269.54	24,156.40	24,052.73	23,958.49
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-28,076.07	-28,520.63	-28,960.86	-29,396.94	-29,829.04	-30,257.32	-30,681.96	-31,103.13	-31,520.98	-31,935.68
Return on Investment		-7%	-7%	-7%	-7%	-7%	-7%	-7%	-7%	-8%	-8%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.025	0.025	0.025	0.025	0.025	0.025	0.026	0.026	0.026	0.026

Appendix

Variant 1.5-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	375		
Padditional [kWel]	100		
CHP 1 [kWel]	250	5,892	1,473,035
CHP 2 (additional CHP) [kWel]	125	5,736	716,964
Total Electricity Production [kWhel/a]	2,189,999		
Additional Earnings Electricity Market [€/kWel; rated a]	45.61		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	180,288.06	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	10,625.00	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
<i>Investment Total without Interest</i>	304,264.39										
Sum	338,726.98	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		106.25	108.38	110.54	112.75	115.01	117.31	119.65	122.05	124.49	126.98
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		100.00	102.00	104.04	106.12	108.24	110.41	112.62	114.87	117.17	119.51
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	89,063.28	8,133.84	8,296.52	8,462.45	8,631.70	8,804.33	8,980.42	9,160.03	9,343.23	9,530.09	9,720.69
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	18,544.83	1,693.63	1,727.51	1,762.06	1,797.30	1,833.24	1,869.91	1,907.31	1,945.45	1,984.36	2,024.05
<i>Other Costs Total without Interest</i>	69,544.83										
Sum	75,321.36	7,371.29	7,405.16	7,439.71	7,474.95	7,510.90	7,547.56	7,584.96	7,623.11	7,662.02	7,701.70
Costs	545,601.24	53,258.26	53,532.41	53,812.05	54,097.29	54,388.23	54,684.99	54,987.68	55,296.42	55,611.35	55,932.57
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	119,109.01	12,999.99	12,745.09	12,495.19	12,250.18	12,009.98	11,774.49	11,543.62	11,317.28	11,095.37	10,877.81
Application Value 0,002 €/kWh	40,130.57	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	124,846.15	11,401.77	11,629.80	11,862.40	12,099.64	12,341.64	12,588.47	12,840.24	13,097.04	13,358.99	13,626.17
Sum	284,085.73	28,781.76	28,669.01	28,567.50	28,477.20	28,398.06	28,330.06	28,273.17	28,227.37	28,192.64	28,168.96
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-24,476.50	-24,863.41	-25,244.55	-25,620.09	-25,990.17	-26,354.92	-26,714.50	-27,069.05	-27,418.71	-27,763.60
Return on Investment		-6%	-6%	-6%	-6%	-6%	-6%	-6%	-7%	-7%	-7%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.024	0.024	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.026

Variant 1.5-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	375		
Padditional [kWel]	100		
CHP 1 [kWel]	250	5,861	1,465,250
CHP 2 (additional CHP) [kWel]	125	5,798	724,750
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	50.17		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	180,288.06	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84	20,070.84
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	10,625.00	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84	1,182.84
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Investment Total without Interest	304,264.39										
Sum	338,726.98	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70	33,872.70
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		106.25	108.38	110.54	112.75	115.01	117.31	119.65	122.05	124.49	126.98
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		100.00	102.00	104.04	106.12	108.24	110.41	112.62	114.87	117.17	119.51
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	89,063.29	8,133.84	8,296.52	8,462.45	8,631.70	8,804.33	8,980.42	9,160.03	9,343.23	9,530.09	9,720.69
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	18,544.83	1,693.63	1,727.51	1,762.06	1,797.30	1,833.24	1,869.91	1,907.31	1,945.45	1,984.36	2,024.05
Other Costs Total without Interest	69,544.83										
Sum	75,321.36	7,371.29	7,405.16	7,439.71	7,474.95	7,510.90	7,547.56	7,584.96	7,623.11	7,662.02	7,701.70
Costs	545,601.25	53,258.26	53,532.41	53,812.06	54,097.29	54,388.23	54,684.99	54,987.68	55,296.43	55,611.35	55,932.57
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	119,109.08	13,000.00	12,745.10	12,495.19	12,250.19	12,009.99	11,774.50	11,543.63	11,317.28	11,095.37	10,877.82
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	137,337.35	12,542.54	12,793.39	13,049.26	13,310.25	13,576.45	13,847.98	14,124.94	14,407.44	14,695.59	14,989.50
Sum	296,577.03	29,922.54	29,832.61	29,754.38	29,687.81	29,632.89	29,589.58	29,557.88	29,537.78	29,529.25	29,532.31
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-23,335.71	-23,699.80	-24,057.68	-24,409.48	-24,755.34	-25,095.40	-25,429.79	-25,758.65	-26,082.10	-26,400.26
Return on Investment		-6%	-6%	-6%	-6%	-6%	-6%	-6%	-6%	-6%	-6%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.024	0.024	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.026

Appendix

Variant 2-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	500		
Padditional [kWel]	225		
CHP 1 [kWel]	250	4,015	1,003,750
CHP 2 (additional CHP) [kWel]	250	4,745	1,186,250
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	43.56		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
Investment Total without Interest	343,097.34										
Sum	381,958.35	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	61,970.51	5,659.55	5,772.74	5,888.20	6,005.96	6,126.08	6,248.60	6,373.57	6,501.05	6,631.07	6,763.69
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	20,911.69	1,909.79	1,947.99	1,986.95	2,026.69	2,067.22	2,108.56	2,150.74	2,193.75	2,237.63	2,282.38
Other Costs Total without Interest	71,911.69										
Sum	77,688.22	7,587.44	7,625.64	7,664.60	7,704.34	7,744.87	7,786.22	7,828.39	7,871.40	7,915.28	7,960.03
Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
	564,106.70	55,323.26	55,552.26	55,785.83	56,024.08	56,267.09	56,514.96	56,767.79	57,025.68	57,288.72	57,557.03
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	267,995.42	29,250.00	28,676.47	28,114.19	27,562.93	27,022.48	26,492.63	25,973.16	25,463.89	24,964.59	24,475.09
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	119,233.46	10,889.18	11,106.96	11,329.10	11,555.68	11,786.80	12,022.53	12,262.98	12,508.24	12,758.41	13,013.58
Sum	427,359.48	44,519.18	44,077.55	43,653.21	43,245.98	42,855.72	42,482.26	42,125.46	41,785.18	41,461.29	41,153.66
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-10,804.08	-11,474.71	-12,132.63	-12,778.10	-13,411.37	-14,032.70	-14,642.33	-15,240.50	-15,827.43	-16,403.37
Return on Investment		-2%	-2%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.025	0.025	0.025	0.026	0.026	0.026	0.026	0.026	0.026	0.026

Variant 2-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	500		
Padditional [kWel]	225		
CHP 1 [kWel]	250	3,651	912,750
CHP 2 (additional CHP) [kWel]	250	5,110	1,277,500
Total Electricity Production [kWhel/a]	2,190,250		
Additional Earnings Electricity Market [€/kWel; rated a]	46.65		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
Investment Total without Interest	343,097.34										
Sum	381,958.35	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.23	1,573.07	1,604.53	1,636.62	1,669.36	1,702.74	1,736.80	1,771.53	1,806.97	1,843.10
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	61,972.44	5,659.73	5,772.92	5,888.38	6,006.15	6,126.27	6,248.80	6,373.77	6,501.25	6,631.27	6,763.90
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	20,911.69	1,909.79	1,947.99	1,986.95	2,026.69	2,067.22	2,108.56	2,150.74	2,193.75	2,237.63	2,282.38
Other Costs Total without Interest	71,911.69										
Sum	77,688.22	7,587.44	7,625.64	7,664.60	7,704.34	7,744.87	7,786.22	7,828.39	7,871.40	7,915.28	7,960.03
Costs	564,108.63	55,323.44	55,552.44	55,786.02	56,024.27	56,267.28	56,515.16	56,767.99	57,025.88	57,288.93	57,557.24
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	268,026.02	29,253.34	28,679.74	28,117.40	27,566.07	27,025.56	26,495.65	25,976.13	25,466.79	24,967.44	24,477.89
Application Value 0,002 €/kWh	40,135.18	4,380.50	4,294.61	4,210.40	4,127.84	4,046.90	3,967.55	3,889.76	3,813.49	3,738.71	3,665.41
Additional Market Profits	127,710.80	11,663.38	11,896.65	12,134.58	12,377.28	12,624.82	12,877.32	13,134.86	13,397.56	13,665.51	13,938.82
Sum	435,871.99	45,297.22	44,871.00	44,462.38	44,071.19	43,697.29	43,340.52	43,000.75	42,677.84	42,371.67	42,082.12
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-10,026.21	-10,681.43	-11,323.63	-11,953.07	-12,569.99	-13,174.63	-13,767.24	-14,348.04	-14,917.26	-15,475.12
Return on Investment		-2%	-2%	-2%	-3%	-3%	-3%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.025	0.025	0.025	0.026	0.026	0.026	0.026	0.026	0.026	0.026

Appendix

Variant 2-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250	3,650	912,500
Installed Capacity [kWel]	500		
Padditional [kWel]	225		
CHP 1 [kWel]	250	5,110	1,277,500
CHP 2 (additional CHP) [kWel]	250		
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	52.42		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
<i>Investment Total without Interest</i>	343,097.34										
Sum	381,958.35	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	61,970.51	5,659.55	5,772.74	5,888.20	6,005.96	6,126.08	6,248.60	6,373.57	6,501.05	6,631.07	6,763.69
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	20,911.69	1,909.79	1,947.99	1,986.95	2,026.69	2,067.22	2,108.56	2,150.74	2,193.75	2,237.63	2,282.38
<i>Other Costs Total without Interest</i>	71,911.69										
Sum	77,688.22	7,587.44	7,625.64	7,664.60	7,704.34	7,744.87	7,786.22	7,828.39	7,871.40	7,915.28	7,960.03
Costs	564,106.70	55,323.26	55,552.26	55,785.83	56,024.08	56,267.09	56,514.96	56,767.79	57,025.68	57,288.72	57,557.03
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	267,995.42	29,250.00	28,676.47	28,114.19	27,562.93	27,022.48	26,492.63	25,973.16	25,463.89	24,964.59	24,475.09
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	143,502.19	13,105.56	13,367.67	13,635.02	13,907.72	14,185.88	14,469.59	14,758.99	15,054.17	15,355.25	15,662.35
Sum	451,628.21	46,735.56	46,338.26	45,959.13	45,598.02	45,254.80	44,929.32	44,621.46	44,331.10	44,058.13	43,802.43
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-8,587.70	-9,214.00	-9,826.70	-10,426.06	-11,012.29	-11,585.64	-12,146.33	-12,694.57	-13,230.59	-13,754.59
Return on Investment		-2%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.025	0.025	0.025	0.026	0.026	0.026	0.026	0.026	0.026	0.026

Variant 2-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	500		
Padditional [kWel]	225		
CHP 1 [kWel]	250	4,380	1,095,000
CHP 2 (additional CHP) [kWel]	250	4,380	1,095,000
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	44.92		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
Investment Total without Interest	405,551.22										
Sum	451,486.09	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	82,486.09	7,533.17	7,683.83	7,837.51	7,994.26	8,154.14	8,317.23	8,483.57	8,653.24	8,826.31	9,002.83
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	24,718.23	2,257.43	2,302.58	2,348.63	2,395.60	2,443.52	2,492.39	2,542.23	2,593.08	2,644.94	2,697.84
Other Costs Total without Interest	75,718.23										
Sum	81,494.76	7,935.08	7,980.23	8,026.28	8,073.26	8,121.17	8,170.04	8,219.89	8,270.73	8,322.59	8,375.49
Costs	657,956.57	64,497.29	64,770.71	65,049.60	65,334.07	65,624.22	65,920.18	66,222.06	66,529.98	66,844.05	67,164.41
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	267,995.42	29,250.00	28,676.47	28,114.19	27,562.93	27,022.48	26,492.63	25,973.16	25,463.89	24,964.59	24,475.09
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	122,955.35	11,229.09	11,453.67	11,682.74	11,916.40	12,154.72	12,397.82	12,645.77	12,898.69	13,156.66	13,419.80
Sum	431,081.37	44,859.09	44,424.26	44,006.85	43,606.70	43,223.64	42,857.54	42,508.25	42,175.63	41,859.54	41,559.88
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-19,638.21	-20,346.46	-21,042.75	-21,727.37	-22,400.58	-23,062.64	-23,713.81	-24,354.35	-24,984.51	-25,604.53
Return on Investment		-4%	-4%	-4%	-4%	-4%	-4%	-4%	-5%	-5%	-5%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.029	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.031	0.031

Appendix

Variant 2-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	500		
Padditional [kWel]	225		
CHP 1 [kWel]	250	4,068	1,017,000
CHP 2 (additional CHP) [kWel]	250	4,693	1,173,250
Total Electricity Production [kWhel/a]	2,190,250		
Additional Earnings Electricity Market [€/kWel; rated a]	54.60		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
<i>Investment Total without Interest</i>	405,551.22										
Sum	451,486.09	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.23	1,573.07	1,604.53	1,636.62	1,669.36	1,702.74	1,736.80	1,771.53	1,806.97	1,843.10
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	82,488.01	7,533.34	7,684.01	7,837.69	7,994.44	8,154.33	8,317.42	8,483.77	8,653.44	8,826.51	9,003.04
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	24,718.23	2,257.43	2,302.58	2,348.63	2,395.60	2,443.52	2,492.39	2,542.23	2,593.08	2,644.94	2,697.84
<i>Other Costs Total without Interest</i>	75,718.23										
Sum	81,494.76	7,935.08	7,980.23	8,026.28	8,073.26	8,121.17	8,170.04	8,219.89	8,270.73	8,322.59	8,375.49
Costs	657,958.50	64,497.47	64,770.89	65,049.78	65,334.25	65,624.41	65,920.38	66,222.26	66,530.18	66,844.26	67,164.62
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	268,026.02	29,253.34	28,679.74	28,117.40	27,566.07	27,025.56	26,495.65	25,976.13	25,466.79	24,967.44	24,477.89
Application Value 0,002 €/kWh	40,135.18	4,380.50	4,294.61	4,210.40	4,127.84	4,046.90	3,967.55	3,889.76	3,813.49	3,738.71	3,665.41
Additional Market Profits	149,464.70	13,650.09	13,923.09	14,201.56	14,485.59	14,775.30	15,070.81	15,372.22	15,679.67	15,993.26	16,313.12
Sum	457,625.90	47,283.93	46,897.45	46,529.35	46,179.51	45,847.77	45,534.01	45,238.11	44,959.95	44,699.42	44,456.42
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-17,213.54	-17,873.44	-18,520.43	-19,154.75	-19,776.65	-20,386.37	-20,984.15	-21,570.23	-22,144.84	-22,708.20
Return on Investment		-3%	-3%	-3%	-4%	-4%	-4%	-4%	-4%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.029	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.031	0.031

Variant 2-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	500		
Padditional [kWel]	225		
CHP 1 [kWel]	250	4,146	1,036,500
CHP 2 (additional CHP) [kWel]	250	4,614	1,153,500
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	63.57		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
Investment Total without Interest	405,551.22										
Sum	451,486.09	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61	45,148.61
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	82,486.09	7,533.17	7,683.83	7,837.51	7,994.26	8,154.14	8,317.23	8,483.57	8,653.24	8,826.31	9,002.83
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	24,718.23	2,257.43	2,302.58	2,348.63	2,395.60	2,443.52	2,492.39	2,542.23	2,593.08	2,644.94	2,697.84
Other Costs Total without Interest	75,718.23										
Sum	81,494.76	7,935.08	7,980.23	8,026.28	8,073.26	8,121.17	8,170.04	8,219.89	8,270.73	8,322.59	8,375.49
Costs	657,956.57	64,497.29	64,770.71	65,049.60	65,334.07	65,624.22	65,920.18	66,222.06	66,529.98	66,844.05	67,164.41
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	267,995.42	29,250.00	28,676.47	28,114.19	27,562.93	27,022.48	26,492.63	25,973.16	25,463.89	24,964.59	24,475.09
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	174,006.86	15,891.44	16,209.27	16,533.46	16,864.13	17,201.41	17,545.44	17,896.35	18,254.27	18,619.36	18,991.74
Sum	482,132.88	49,521.44	49,179.86	48,857.56	48,554.43	48,270.33	48,005.16	47,758.82	47,531.21	47,322.24	47,131.82
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-14,975.85	-15,590.85	-16,192.04	-16,779.64	-17,353.89	-17,915.02	-18,463.24	-18,998.77	-19,521.81	-20,032.58
Return on Investment		-3%	-3%	-3%	-3%	-3%	-3%	-3%	-4%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.029	0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.031	0.031

Appendix

Variant 2-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	500		
Padditional [kWel]	225		
CHP 1 [kWel]	250	4,380	1,095,000
CHP 2 (additional CHP) [kWel]	250	4,380	1,095,000
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	44.92		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Control System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Transformer / Grid	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
#BEZUG!	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
Sum	432,448.66										
Supply Costs	481,430.08	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	91,321.67	8,340.09	8,506.89	8,677.03	8,850.57	9,027.58	9,208.13	9,392.30	9,580.14	9,771.75	9,967.18
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	26,357.63	2,407.15	2,455.29	2,504.40	2,554.49	2,605.58	2,657.69	2,710.84	2,765.06	2,820.36	2,876.77
Other Costs Total without Interest	77,357.63										
Sum	83,134.15	8,084.80	8,132.95	8,182.05	8,232.14	8,283.23	8,335.34	8,388.50	8,442.71	8,498.01	8,554.42
Costs	698,375.53	68,448.33	68,740.89	69,039.29	69,343.66	69,654.12	69,970.79	70,293.79	70,623.26	70,959.31	71,302.08
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	267,995.42	29,250.00	28,676.47	28,114.19	27,562.93	27,022.48	26,492.63	25,973.16	25,463.89	24,964.59	24,475.09
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	122,955.35	11,229.09	11,453.67	11,682.74	11,916.40	12,154.72	12,397.82	12,645.77	12,898.69	13,156.66	13,419.80
Sum	431,081.37	44,859.09	44,424.26	44,006.85	43,606.70	43,223.64	42,857.54	42,508.25	42,175.63	41,859.54	41,559.88
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-23,589.25	-24,316.63	-25,032.44	-25,736.97	-26,430.48	-27,113.25	-27,785.54	-28,447.63	-29,099.76	-29,742.21	-30,384.21
Return on Investment		-4%	-4%	-4%	-5%	-5%	-5%	-5%	-5%	-5%	-5%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.031	0.031	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.033

Variant 2-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	500		
Padditional [kWel]	225		
CHP 1 [kWel]	250	4,225	1,056,250
CHP 2 (additional CHP) [kWel]	250	4,537	1,134,250
Total Electricity Production [kWhel/a]	2,190,500		
Additional Earnings Electricity Market [€/kWel; rated a]	62.06		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
Investment Total without Interest	432,448.66										
Sum	481,430.08	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.40	1,573.25	1,604.72	1,636.81	1,669.55	1,702.94	1,737.00	1,771.74	1,807.17	1,843.31
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	91,325.53	8,340.44	8,507.25	8,677.40	8,850.95	9,027.96	9,208.52	9,392.69	9,580.55	9,772.16	9,967.60
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	26,357.63	2,407.15	2,455.29	2,504.40	2,554.49	2,605.58	2,657.69	2,710.84	2,765.06	2,820.36	2,876.77
Other Costs Total without Interest	77,357.63										
Sum	83,134.15	8,084.80	8,132.95	8,182.05	8,232.14	8,283.23	8,335.34	8,388.50	8,442.71	8,498.01	8,554.42
Costs	698,379.38	68,448.68	68,741.24	69,039.66	69,344.04	69,654.50	69,971.18	70,294.19	70,623.66	70,959.72	71,302.50
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	268,056.61	29,256.68	28,683.02	28,120.61	27,569.22	27,028.65	26,498.67	25,979.09	25,469.70	24,970.29	24,480.68
Application Value 0,002 €/kWh	40,139.76	4,381.00	4,295.10	4,210.88	4,128.31	4,047.37	3,968.01	3,890.20	3,813.92	3,739.14	3,665.82
Additional Market Profits	169,881.92	15,514.73	15,825.02	16,141.52	16,464.35	16,793.64	17,129.51	17,472.10	17,821.54	18,177.97	18,541.53
Sum	478,078.29	49,152.40	48,803.14	48,473.01	48,161.89	47,869.65	47,596.19	47,341.40	47,105.17	46,887.41	46,688.04
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-19,296.28	-19,938.11	-20,566.65	-21,182.15	-21,784.85	-22,374.99	-22,952.79	-23,518.50	-24,072.31	-24,614.47
Return on Investment		-3%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.031	0.031	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.033

Appendix

Variant 2-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	500		
Padditional [kWel]	225		
CHP 1 [kWel]	250	4,275	1,068,750
CHP 2 (additional CHP) [kWel]	250	4,485	1,121,250
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	71.98		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
<i>Investment Total without Interest</i>	432,448.66										
Sum	481,430.08	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01	48,143.01
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	91,321.67	8,340.09	8,506.89	8,677.03	8,850.57	9,027.58	9,208.13	9,392.30	9,580.14	9,771.75	9,967.18
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	26,357.63	2,407.15	2,455.29	2,504.40	2,554.49	2,605.58	2,657.69	2,710.84	2,765.06	2,820.36	2,876.77
<i>Other Costs Total without Interest</i>	77,357.63										
Sum	83,134.15	8,084.80	8,132.95	8,182.05	8,232.14	8,283.23	8,335.34	8,388.50	8,442.71	8,498.01	8,554.42
Costs	698,375.53	68,448.33	68,740.89	69,039.29	69,343.66	69,654.12	69,970.79	70,293.79	70,623.26	70,959.31	71,302.08
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	267,995.42	29,250.00	28,676.47	28,114.19	27,562.93	27,022.48	26,492.63	25,973.16	25,463.89	24,964.59	24,475.09
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	197,046.53	17,995.58	18,355.49	18,722.60	19,097.05	19,478.99	19,868.57	20,265.94	20,671.26	21,084.68	21,506.38
Sum	505,172.55	51,625.58	51,326.07	51,046.70	50,787.35	50,547.91	50,328.30	50,128.42	49,948.20	49,787.57	49,646.46
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-16,822.76	-17,414.81	-17,992.59	-18,556.31	-19,106.21	-19,642.50	-20,165.38	-20,675.06	-21,171.74	-21,655.62
Return on Investment		-3%	-3%	-3%	-3%	-3%	-3%	-4%	-4%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.031	0.031	0.032	0.032	0.032	0.032	0.032	0.032	0.032	0.033

Variant 3-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	750		
Padditional [kWel]	475		
CHP 1 [kWel]	250	4,380	1,095,000
CHP 2 (additional CHP) [kWel]	500	2,190	1,095,000
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	52.64		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	556,076.13										
Sum	619,060.25	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	66,487.27	6,072.05	6,193.49	6,317.36	6,443.71	6,572.58	6,704.04	6,838.12	6,974.88	7,114.38	7,256.66
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	33,892.68	3,095.30	3,157.21	3,220.35	3,284.76	3,350.45	3,417.46	3,485.81	3,555.53	3,626.64	3,699.17
Other Costs Total without Interest	84,892.68										
Sum	90,669.21	8,772.95	8,834.86	8,898.00	8,962.41	9,028.11	9,095.12	9,163.46	9,233.18	9,304.29	9,376.82
Costs	818,706.36	80,631.46	80,892.42	81,158.59	81,430.09	81,707.02	81,989.48	82,277.60	82,571.48	82,871.23	83,176.99
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	446,659.04	48,750.00	47,794.12	46,856.98	45,938.21	45,037.46	44,154.38	43,288.60	42,439.81	41,607.66	40,791.82
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	144,097.05	13,159.88	13,423.08	13,691.54	13,965.37	14,244.68	14,529.57	14,820.17	15,116.57	15,418.90	15,727.28
Sum	630,886.68	66,289.88	65,511.32	64,758.44	64,030.96	63,328.59	62,651.05	61,998.09	61,369.43	60,764.84	60,184.09
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-14,341.58	-15,381.10	-16,400.15	-17,399.13	-18,378.43	-19,338.43	-20,279.52	-21,202.05	-22,106.39	-22,992.90
Return on Investment		-2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.037	0.037	0.037	0.037	0.037	0.037	0.038	0.038	0.038	0.038

Appendix

Variant 3-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	750		
Padditional [kWel]	475		
CHP 1 [kWel]	250	4,277	1,069,250
CHP 2 (additional CHP) [kWel]	500	2,242	1,121,000
Total Electricity Production [kWhel/a]	2,190,250		
Additional Earnings Electricity Market [€/kWel; rated a]	56.84		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	556,076.13										
Sum	619,060.25	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.23	1,573.07	1,604.53	1,636.62	1,669.36	1,702.74	1,736.80	1,771.53	1,806.97	1,843.10
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	66,489.20	6,072.23	6,193.67	6,317.55	6,443.90	6,572.77	6,704.23	6,838.31	6,975.08	7,114.58	7,256.87
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	33,892.68	3,095.30	3,157.21	3,220.35	3,284.76	3,350.45	3,417.46	3,485.81	3,555.53	3,626.64	3,699.17
Other Costs Total without Interest	84,892.68										
Sum	90,669.21	8,772.95	8,834.86	8,898.00	8,962.41	9,028.11	9,095.12	9,163.46	9,233.18	9,304.29	9,376.82
Costs											
	818,708.28	80,631.64	80,892.60	81,158.77	81,430.28	81,707.21	81,989.68	82,277.80	82,571.68	82,871.44	83,177.20
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	446,710.03	48,755.57	47,799.57	46,862.33	45,943.46	45,042.61	44,159.42	43,293.55	42,444.65	41,612.41	40,796.48
Application Value 0,002 €/kWh	40,135.18	4,380.50	4,294.61	4,210.40	4,127.84	4,046.90	3,967.55	3,889.76	3,813.49	3,738.71	3,665.41
Additional Market Profits	155,609.15	14,211.24	14,495.47	14,785.38	15,081.08	15,382.71	15,690.36	16,004.17	16,324.25	16,650.74	16,983.75
Sum	642,454.35	67,347.31	66,589.65	65,858.10	65,152.39	64,472.22	63,817.33	63,187.47	62,582.39	62,001.86	61,445.63
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-13,284.33	-14,302.95	-15,300.67	-16,277.89	-17,234.99	-18,172.35	-19,090.33	-19,989.29	-20,869.58	-21,731.56
Return on Investment		-2%	-2%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.037	0.037	0.037	0.037	0.037	0.037	0.038	0.038	0.038	0.038

Variant 3-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	750		
Padditional [kWel]	475		
CHP 1 [kWel]	250	4,246	1,061,500
CHP 2 (additional CHP) [kWel]	500	2,257	1,128,500
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	63.81		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	556,076.13										
Sum	619,060.25	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	66,487.27	6,072.05	6,193.49	6,317.36	6,443.71	6,572.58	6,704.04	6,838.12	6,974.88	7,114.38	7,256.66
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	33,892.68	3,095.30	3,157.21	3,220.35	3,284.76	3,350.45	3,417.46	3,485.81	3,555.53	3,626.64	3,699.17
Other Costs Total without Interest	84,892.68										
Sum	90,669.21	8,772.95	8,834.86	8,898.00	8,962.41	9,028.11	9,095.12	9,163.46	9,233.18	9,304.29	9,376.82
Costs	818,706.36	80,631.46	80,892.42	81,158.59	81,430.09	81,707.02	81,989.48	82,277.60	82,571.48	82,871.23	83,176.99
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	446,659.04	48,750.00	47,794.12	46,856.98	45,938.21	45,037.46	44,154.38	43,288.60	42,439.81	41,607.66	40,791.82
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	174,686.62	15,953.52	16,272.59	16,598.05	16,930.01	17,268.61	17,613.98	17,966.26	18,325.58	18,692.09	19,065.94
Sum	661,476.26	69,083.52	68,360.83	67,664.94	66,995.59	66,352.51	65,735.46	65,144.18	64,578.45	64,038.04	63,522.74
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-11,547.94	-12,531.59	-13,493.65	-14,434.50	-15,354.50	-16,254.03	-17,133.42	-17,993.03	-18,833.20	-19,654.24
Return on Investment		-2%	-2%	-2%	-2%	-2%	-2%	-2%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.037	0.037	0.037	0.037	0.037	0.037	0.038	0.038	0.038	0.038

Appendix

Variant 3-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	750		
Padditional [kWel]	475		
CHP 1 [kWel]	250	2,920	730,000
CHP 2 (additional CHP) [kWel]	500	2,920	1,460,000
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	57.46		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Control System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Transformer / Grid	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
#BEZUG!	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Sum	618,530.02										
Supply Costs	688,587.99	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	87,002.85	7,945.67	8,104.58	8,266.67	8,432.01	8,600.65	8,772.66	8,948.11	9,127.07	9,309.62	9,495.81
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	37,699.23	3,442.94	3,511.80	3,582.03	3,653.68	3,726.75	3,801.28	3,877.31	3,954.86	4,033.95	4,114.63
Other Costs Total without Interest	88,699.23										
Sum	94,475.76	9,120.59	9,189.45	9,259.69	9,331.33	9,404.40	9,478.94	9,554.96	9,632.51	9,711.61	9,792.28
Costs	912,556.22	89,805.49	90,110.87	90,422.36	90,740.08	91,064.15	91,394.70	91,731.87	92,075.78	92,426.56	92,784.37
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	446,659.04	48,750.00	47,794.12	46,856.98	45,938.21	45,037.46	44,154.38	43,288.60	42,439.81	41,607.66	40,791.82
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	157,284.29	14,364.23	14,651.51	14,944.54	15,243.43	15,548.30	15,859.27	16,176.45	16,499.98	16,829.98	17,166.58
Sum	644,073.92	67,494.23	66,739.75	66,011.44	65,309.02	64,632.21	63,980.75	63,354.37	62,752.84	62,175.93	61,623.39
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-22,311.26	-23,371.12	-24,410.92	-25,431.06	-26,431.94	-27,413.96	-28,377.50	-29,322.93	-30,250.64	-31,160.98
Return on Investment		-3%	-3%	-3%	-3%	-3%	-3%	-4%	-4%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.041	0.041	0.041	0.041	0.042	0.042	0.042	0.042	0.042	0.042

Variant 3-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	750		
Padditional [kWel]	475		
CHP 1 [kWel]	250	3,130	782,500
CHP 2 (additional CHP) [kWel]	500	2,816	1,408,000
Total Electricity Production [kWhel/a]	2,190,500		
Additional Earnings Electricity Market [€/kWel; rated a]	69.66		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	618,530.02										
Sum	688,587.99	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.40	1,573.25	1,604.72	1,636.81	1,669.55	1,702.94	1,737.00	1,771.74	1,807.17	1,843.31
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	87,006.70	7,946.02	8,104.94	8,267.04	8,432.38	8,601.03	8,773.05	8,948.51	9,127.48	9,310.03	9,496.23
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	37,699.23	3,442.94	3,511.80	3,582.03	3,653.68	3,726.75	3,801.28	3,877.31	3,954.86	4,033.95	4,114.63
Other Costs Total without Interest	88,699.23										
Sum	94,475.76	9,120.59	9,189.45	9,259.69	9,331.33	9,404.40	9,478.94	9,554.96	9,632.51	9,711.61	9,792.28
Costs	912,560.08	89,805.84	90,111.23	90,422.73	90,740.45	91,064.53	91,395.09	91,732.26	92,076.18	92,426.98	92,784.79
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	446,761.02	48,761.13	47,805.03	46,867.68	45,948.70	45,047.75	44,164.46	43,298.49	42,449.50	41,617.16	40,801.13
Application Value 0,002 €/kWh	40,139.76	4,381.00	4,295.10	4,210.88	4,128.31	4,047.37	3,968.01	3,890.20	3,813.92	3,739.14	3,665.82
Additional Market Profits	190,695.95	17,415.60	17,763.91	18,119.19	18,481.57	18,851.20	19,228.23	19,612.79	20,005.05	20,405.15	20,813.25
Sum	677,596.73	70,557.73	69,864.04	69,197.75	68,558.59	67,946.32	67,360.69	66,801.48	66,268.47	65,761.45	65,280.21
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-19,248.11	-20,247.19	-21,224.98	-22,181.86	-23,118.21	-24,034.40	-24,930.78	-25,807.71	-26,665.53	-27,504.58
Return on Investment		-2%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.041	0.041	0.041	0.041	0.042	0.042	0.042	0.042	0.042	0.042

Appendix

Variant 3-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250	3,174	793,500
Installed Capacity [kWel]	750		
Padditional [kWel]	475		
CHP 1 [kWel]	250	2,793	1,396,500
CHP 2 (additional CHP) [kWel]	500		
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	81.20		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	898

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	62,453.89	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77	6,952.77
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
<i>Investment Total without Interest</i>	618,530.02										
Sum	688,587.99	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80	68,858.80
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,173.62	2,217.09	2,261.43	2,306.66	2,352.79	2,399.85	2,447.85	2,496.80	2,546.74	2,597.67
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	87,002.85	7,945.67	8,104.58	8,266.67	8,432.01	8,600.65	8,772.66	8,948.11	9,127.07	9,309.62	9,495.81
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	37,699.23	3,442.94	3,511.80	3,582.03	3,653.68	3,726.75	3,801.28	3,877.31	3,954.86	4,033.95	4,114.63
<i>Other Costs Total without Interest</i>	88,699.23										
Sum	94,475.76	9,120.59	9,189.45	9,259.69	9,331.33	9,404.40	9,478.94	9,554.96	9,632.51	9,711.61	9,792.28
Costs	912,556.22	89,805.49	90,110.87	90,422.36	90,740.08	91,064.15	91,394.70	91,731.87	92,075.78	92,426.56	92,784.37
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	446,659.04	48,750.00	47,794.12	46,856.98	45,938.21	45,037.46	44,154.38	43,288.60	42,439.81	41,607.66	40,791.82
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	222,278.43	20,299.92	20,705.92	21,120.03	21,542.43	21,973.28	22,412.75	22,861.00	23,318.22	23,784.59	24,260.28
Sum	709,068.07	73,429.92	72,794.15	72,186.93	71,608.02	71,057.19	70,534.23	70,038.92	69,571.09	69,130.53	68,717.09
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-16,375.57	-17,316.72	-18,235.43	-19,132.06	-20,006.96	-20,860.48	-21,692.94	-22,504.69	-23,296.03	-24,067.28	-24,817.38
Return on Investment	-2%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.041	0.041	0.041	0.041	0.042	0.042	0.042	0.042	0.042	0.042

Variant 3-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	750		
Padditional [kWel]	475		
CHP 1 [kWel]	250	2,920	730,000
CHP 2 (additional CHP) [kWel]	500	2,920	1,460,000
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	57.46		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	645,427.45										
Sum	718,531.97	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	95,838.43	8,752.59	8,927.64	9,106.20	9,288.32	9,474.09	9,663.57	9,856.84	10,053.98	10,255.06	10,460.16
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	39,338.62	3,592.66	3,664.51	3,737.80	3,812.56	3,888.81	3,966.59	4,045.92	4,126.84	4,209.37	4,293.56
Other Costs Total without Interest	90,338.62										
Sum	96,115.15	9,270.31	9,342.17	9,415.46	9,490.21	9,566.46	9,644.24	9,723.57	9,804.49	9,887.03	9,971.21
Costs	952,975.18	93,756.53	94,081.04	94,412.05	94,749.67	95,094.05	95,445.31	95,803.60	96,169.06	96,541.82	96,922.04
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	446,659.04	48,750.00	47,794.12	46,856.98	45,938.21	45,037.46	44,154.38	43,288.60	42,439.81	41,607.66	40,791.82
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	157,284.29	14,364.23	14,651.51	14,944.54	15,243.43	15,548.30	15,859.27	16,176.45	16,499.98	16,829.98	17,166.58
Sum	644,073.92	67,494.23	66,739.75	66,011.44	65,309.02	64,632.21	63,980.75	63,354.37	62,752.84	62,175.93	61,623.39
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-26,262.30	-27,341.30	-28,400.61	-29,440.65	-30,461.84	-31,464.57	-32,449.23	-33,416.21	-34,365.90	-35,298.65
Return on Investment		-3%	-3%	-3%	-4%	-4%	-4%	-4%	-4%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.043	0.043	0.043	0.043	0.043	0.044	0.044	0.044	0.044	0.044

Appendix

Variant 3-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	750		
Padditional [kWel]	475		
CHP 1 [kWel]	250	3,026	756,500
CHP 2 (additional CHP) [kWel]	500	2,868	1,434,000
Total Electricity Production [kWhel/a]	2,190,500		
Additional Earnings Electricity Market [€/kWel; rated a]	78.29		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	645,427.45										
Sum	718,531.97	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.40	1,573.25	1,604.72	1,636.81	1,669.55	1,702.94	1,737.00	1,771.74	1,807.17	1,843.31
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	95,842.29	8,752.94	8,928.00	9,106.56	9,288.69	9,474.47	9,663.96	9,857.24	10,054.38	10,255.47	10,460.58
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	39,338.62	3,592.66	3,664.51	3,737.80	3,812.56	3,888.81	3,966.59	4,045.92	4,126.84	4,209.37	4,293.56
Other Costs Total without Interest	90,338.62										
Sum	96,115.15	9,270.31	9,342.17	9,415.46	9,490.21	9,566.46	9,644.24	9,723.57	9,804.49	9,887.03	9,971.21
Costs											
	952,979.04	93,756.88	94,081.40	94,412.41	94,750.05	95,094.43	95,445.70	95,804.00	96,169.46	96,542.23	96,922.46
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	446,761.02	48,761.13	47,805.03	46,867.68	45,948.70	45,047.75	44,164.46	43,298.49	42,449.50	41,617.16	40,801.13
Application Value 0,002 €/kWh	40,139.76	4,381.00	4,295.10	4,210.88	4,128.31	4,047.37	3,968.01	3,890.20	3,813.92	3,739.14	3,665.82
Additional Market Profits	214,309.68	19,572.16	19,963.60	20,362.87	20,770.13	21,185.53	21,609.24	22,041.43	22,482.26	22,931.90	23,390.54
Sum	701,210.45	72,714.29	72,063.73	71,441.43	70,847.15	70,280.65	69,741.71	69,230.12	68,745.68	68,288.20	67,857.50
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-21,042.59	-22,017.67	-22,970.98	-23,902.90	-24,813.78	-25,703.99	-26,573.88	-27,423.78	-28,254.03	-29,064.96
Return on Investment		-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.043	0.043	0.043	0.043	0.043	0.044	0.044	0.044	0.044	0.044

Variant 3-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	250		
Installed Capacity [kWel]	750		
Padditional [kWel]	475		
CHP 1 [kWel]	250	3,052	763,000
CHP 2 (additional CHP) [kWel]	500	2,854	1,427,000
Total Electricity Production [kWhel/a]	2,190,000		
Additional Earnings Electricity Market [€/kWel; rated a]	92.80		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	645,427.45										
Sum	718,531.97	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20	71,853.20
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		47.93	48.89	49.87	50.86	51.88	52.92	53.98	55.06	56.16	57.28
Sum	42,489.62	3,880.43	3,958.04	4,037.20	4,117.94	4,200.30	4,284.31	4,369.99	4,457.39	4,546.54	4,637.47
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		1,542.05	1,572.89	1,604.35	1,636.44	1,669.17	1,702.55	1,736.60	1,771.33	1,806.76	1,842.89
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	95,838.43	8,752.59	8,927.64	9,106.20	9,288.32	9,474.09	9,663.57	9,856.84	10,053.98	10,255.06	10,460.16
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	39,338.62	3,592.66	3,664.51	3,737.80	3,812.56	3,888.81	3,966.59	4,045.92	4,126.84	4,209.37	4,293.56
Other Costs Total without Interest	90,338.62										
Sum	96,115.15	9,270.31	9,342.17	9,415.46	9,490.21	9,566.46	9,644.24	9,723.57	9,804.49	9,887.03	9,971.21
Costs	952,975.18	93,756.53	94,081.04	94,412.05	94,749.67	95,094.05	95,445.31	95,803.60	96,169.06	96,541.82	96,922.04
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	446,659.04	48,750.00	47,794.12	46,856.98	45,938.21	45,037.46	44,154.38	43,288.60	42,439.81	41,607.66	40,791.82
Application Value 0,002 €/kWh	40,130.60	4,380.00	4,294.12	4,209.92	4,127.37	4,046.44	3,967.10	3,889.31	3,813.05	3,738.29	3,664.99
Additional Market Profits	254,045.19	23,201.07	23,665.09	24,138.39	24,621.16	25,113.58	25,615.85	26,128.17	26,650.73	27,183.75	27,727.42
Sum	740,834.82	76,331.07	75,753.32	75,205.29	74,686.74	74,197.49	73,737.33	73,306.09	72,903.59	72,529.69	72,184.23
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-17,425.47	-18,327.72	-19,206.76	-20,062.93	-20,896.56	-21,707.98	-22,497.52	-23,265.46	-24,012.13	-24,737.81	-25,473.81
Return on Investment		-2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.043	0.043	0.043	0.043	0.043	0.044	0.044	0.044	0.044	0.044

A.2 $P_{\text{rated}} = 550 \text{ kW}_{\text{el}}$

Variant 1.25-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	688		
Padditional [kWel]	83		
CHP 1 [kWel]	550	6,935	3,814,250
CHP 2 (additional CHP) [kWel]	138	7,300	1,003,750
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	192,268.01	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	11,687.50	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	11,000.00	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59
<i>Investment Total without Interest</i>	228,955.51										
Sum	254,888.22	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		110.00	112.20	114.44	116.73	119.07	121.45	123.88	126.36	128.88	131.46
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	71,397.57	6,520.49	6,650.90	6,783.92	6,919.60	7,057.99	7,199.15	7,343.13	7,490.00	7,639.80	7,792.59
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	13,954.77	1,274.44	1,299.93	1,325.93	1,352.45	1,379.50	1,407.09	1,435.23	1,463.93	1,493.21	1,523.08
<i>Other Costs Total without Interest</i>	64,954.77										
Sum	70,731.30	6,952.09	6,977.58	7,003.58	7,030.10	7,057.15	7,084.74	7,112.88	7,141.59	7,170.86	7,200.73
Costs	440,500.73	42,932.62	43,167.94	43,407.97	43,652.80	43,902.53	44,157.25	44,417.06	44,682.07	44,952.39	45,228.10
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	98,264.99	10,725.00	10,514.71	10,308.54	10,106.41	9,908.24	9,713.96	9,523.49	9,336.76	9,153.68	8,974.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	132,423.74	12,093.80	12,335.68	12,582.39	12,834.04	13,090.72	13,352.53	13,619.58	13,891.98	14,169.82	14,453.21
Sum	318,976.05	32,454.80	32,297.44	32,152.75	32,020.66	31,901.14	31,794.12	31,699.57	31,617.45	31,547.73	31,490.39
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-10,477.82	-10,870.50	-11,255.22	-11,632.14	-12,001.39	-12,363.13	-12,717.49	-13,064.62	-13,404.65	-13,737.72
Return on Investment		-3%	-3%	-3%	-4%	-4%	-4%	-4%	-4%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009

Variant 1.25-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	688		
Padditional [kWel]	83		
CHP 1 [kWel]	550	7,094	3,901,700
CHP 2 (additional CHP) [kWel]	138	6,675	917,813
Total Electricity Production [kWhel/a]	4,819,513		
Additional Earnings Electricity Market [€/kWel; rated a]	23.85		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	192,268.01	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	11,687.50	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	11,000.00	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59
Investment Total without Interest	228,955.51										
Sum	254,888.22	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,706.34	2,760.47	2,815.68	2,871.99	2,929.43	2,988.02	3,047.78	3,108.74	3,170.91	3,234.33
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		116.88	119.21	121.60	124.03	126.51	129.04	131.62	134.25	136.94	139.68
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		110.00	112.20	114.44	116.73	119.07	121.45	123.88	126.36	128.88	131.46
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	72,686.61	6,638.22	6,770.98	6,906.40	7,044.53	7,185.42	7,329.13	7,475.71	7,625.22	7,777.73	7,933.28
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	13,954.77	1,274.44	1,299.93	1,325.93	1,352.45	1,379.50	1,407.09	1,435.23	1,463.93	1,493.21	1,523.08
Other Costs Total without Interest	64,954.77										
Sum	70,731.30	6,952.09	6,977.58	7,003.58	7,030.10	7,057.15	7,084.74	7,112.88	7,141.59	7,170.86	7,200.73
Costs	441,789.78	43,050.34	43,288.02	43,530.45	43,777.73	44,029.95	44,287.22	44,549.64	44,817.30	45,090.32	45,368.80
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	98,295.84	10,728.37	10,518.01	10,311.77	10,109.58	9,911.35	9,717.01	9,526.48	9,339.69	9,156.56	8,977.02
Application Value 0,002 €/kWh	88,315.03	9,639.03	9,450.02	9,264.73	9,083.07	8,904.97	8,730.36	8,559.18	8,391.35	8,226.82	8,065.50
Additional Market Profits	143,616.64	13,116.01	13,378.33	13,645.90	13,918.81	14,197.19	14,481.13	14,770.76	15,066.17	15,367.50	15,674.85
Sum	330,227.51	33,483.40	33,346.36	33,222.40	33,111.46	33,013.51	32,928.51	32,856.42	32,797.21	32,750.87	32,717.37
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-9,566.94	-9,941.66	-10,308.05	-10,666.27	-11,016.44	-11,358.72	-11,693.22	-12,020.09	-12,339.45	-12,651.43
Return on Investment		-3%	-3%	-3%	-3%	-3%	-3%	-4%	-4%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009

Appendix

Variant 1.25-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	688		
Padditional [kWel]	83		
CHP 1 [kWel]	550	7,070	3,888,500
CHP 2 (additional CHP) [kWel]	138	6,760	929,500
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	26.24		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	192,268.01	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	11,687.50	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	11,000.00	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59
Investment Total without Interest	228,955.51										
Sum	254,888.22	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82	25,488.82
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		116.88	119.21	121.60	124.03	126.51	129.04	131.62	134.25	136.94	139.68
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		110.00	112.20	114.44	116.73	119.07	121.45	123.88	126.36	128.88	131.46
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	72,677.31	6,637.37	6,770.11	6,905.52	7,043.63	7,184.50	7,328.19	7,474.75	7,624.25	7,776.73	7,932.27
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	13,954.77	1,274.44	1,299.93	1,325.93	1,352.45	1,379.50	1,407.09	1,435.23	1,463.93	1,493.21	1,523.08
Other Costs Total without Interest	64,954.77										
Sum	70,731.30	6,952.09	6,977.58	7,003.58	7,030.10	7,057.15	7,084.74	7,112.88	7,141.59	7,170.86	7,200.73
Costs											
	441,780.48	43,049.49	43,287.15	43,529.57	43,776.83	44,029.04	44,286.29	44,548.68	44,816.33	45,089.32	45,367.78
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	98,264.99	10,725.00	10,514.71	10,308.54	10,106.41	9,908.24	9,713.96	9,523.49	9,336.76	9,153.68	8,974.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	158,024.93	14,431.87	14,720.51	15,014.92	15,315.21	15,621.52	15,933.95	16,252.63	16,577.68	16,909.23	17,247.42
Sum	344,577.23	34,792.87	34,682.27	34,585.27	34,501.84	34,431.94	34,375.53	34,332.61	34,303.16	34,287.15	34,284.59
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-8,256.62	-8,604.88	-8,944.29	-9,274.99	-9,597.10	-9,910.75	-10,216.07	-10,513.17	-10,802.17	-11,083.19
Return on Investment		-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009

Variant 1.25-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	688		
Padditional [kWel]	83		
CHP 1 [kWel]	550	6,935	3,814,250
CHP 2 (additional CHP) [kWel]	138	7,300	1,003,750
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	192,268.01	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	11,687.50	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	11,000.00	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59
Investment Total without Interest	309,714.20										
Sum	344,794.06	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System		116.88	119.21	121.60	124.03	126.51	129.04	131.62	134.25	136.94	139.68
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		110.00	112.20	114.44	116.73	119.07	121.45	123.88	126.36	128.88	131.46
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	99,205.87	9,060.13	9,241.33	9,426.16	9,614.68	9,806.97	10,003.11	10,203.18	10,407.24	10,615.38	10,827.69
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	18,876.99	1,723.97	1,758.45	1,793.62	1,829.49	1,866.08	1,903.40	1,941.47	1,980.30	2,019.91	2,060.30
Other Costs Total without Interest	69,876.99										
Sum	75,653.52	7,401.62	7,436.10	7,471.27	7,507.14	7,543.73	7,581.06	7,619.12	7,657.95	7,697.56	7,737.96
Costs	563,137.09	54,912.37	55,207.47	55,508.48	55,815.51	56,128.68	56,448.11	56,773.93	57,106.27	57,445.25	57,791.02
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	98,264.99	10,725.00	10,514.71	10,308.54	10,106.41	9,908.24	9,713.96	9,523.49	9,336.76	9,153.68	8,974.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	132,423.74	12,093.80	12,335.68	12,582.39	12,834.04	13,090.72	13,352.53	13,619.58	13,891.98	14,169.82	14,453.21
Sum	318,976.05	32,454.80	32,297.44	32,152.75	32,020.66	31,901.14	31,794.12	31,699.57	31,617.45	31,547.73	31,490.39
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-22,457.57	-22,910.03	-23,355.73	-23,794.85	-24,227.54	-24,653.99	-25,074.36	-25,488.82	-25,897.52	-26,300.63
Return on Investment		-5%	-5%	-6%	-6%	-6%	-6%	-6%	-6%	-6%	-6%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012

Appendix

Variant 1.25-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	688		
Padditional [kWel]	83		
CHP 1 [kWel]	550	7,093	3,901,150
CHP 2 (additional CHP) [kWel]	138	6,675	917,813
Total Electricity Production [kWhel/a]	4,818,963		
Additional Earnings Electricity Market [€/kWel; rated a]	26.55		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	192,268.01	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	11,687.50	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	11,000.00	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59
Investment Total without Interest	309,714.20										
Sum	344,794.06	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,706.03	2,760.15	2,815.36	2,871.66	2,929.10	2,987.68	3,047.43	3,108.38	3,170.55	3,233.96
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System		116.88	119.21	121.60	124.03	126.51	129.04	131.62	134.25	136.94	139.68
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		110.00	112.20	114.44	116.73	119.07	121.45	123.88	126.36	128.88	131.46
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	99,211.79	9,060.67	9,241.88	9,426.72	9,615.25	9,807.56	10,003.71	10,203.78	10,407.86	10,616.02	10,828.34
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	18,876.99	1,723.97	1,758.45	1,793.62	1,829.49	1,866.08	1,903.40	1,941.47	1,980.30	2,019.91	2,060.30
Other Costs Total without Interest	69,876.99										
Sum	75,653.52	7,401.62	7,436.10	7,471.27	7,507.14	7,543.73	7,581.06	7,619.12	7,657.95	7,697.56	7,737.96
Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
	563,143.01	54,912.91	55,208.02	55,509.04	55,816.08	56,129.26	56,448.71	56,774.54	57,106.89	57,445.89	57,791.66
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	98,284.62	10,727.14	10,516.81	10,310.59	10,108.43	9,910.22	9,715.90	9,525.40	9,338.62	9,155.51	8,975.99
Application Value 0,002 €/kWh	88,304.95	9,637.93	9,448.95	9,263.67	9,082.03	8,903.95	8,729.37	8,558.20	8,390.39	8,225.88	8,064.58
Additional Market Profits	159,922.30	14,605.15	14,897.25	15,195.20	15,499.10	15,809.08	16,125.26	16,447.77	16,776.72	17,112.26	17,454.50
Sum	346,511.87	34,970.22	34,863.00	34,769.46	34,689.56	34,623.26	34,570.53	34,531.37	34,505.74	34,493.65	34,495.08
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-19,942.69	-20,345.02	-20,739.58	-21,126.53	-21,506.01	-21,878.17	-22,243.17	-22,601.15	-22,952.24	-23,296.58	-23,639.58
Return on Investment		-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-6%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012

Variant 1.25-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	688		
Padditional [kWel]	83		
CHP 1 [kWel]	550	7,045	3,874,750
CHP 2 (additional CHP) [kWel]	138	6,860	943,250
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	30.23		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	192,268.01	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	11,687.50	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	11,000.00	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59
Investment Total without Interest	309,714.20										
Sum	344,794.06	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41	34,479.41
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System		116.88	119.21	121.60	124.03	126.51	129.04	131.62	134.25	136.94	139.68
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		110.00	112.20	114.44	116.73	119.07	121.45	123.88	126.36	128.88	131.46
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	99,205.87	9,060.13	9,241.33	9,426.16	9,614.68	9,806.97	10,003.11	10,203.18	10,407.24	10,615.38	10,827.69
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	18,876.99	1,723.97	1,758.45	1,793.62	1,829.49	1,866.08	1,903.40	1,941.47	1,980.30	2,019.91	2,060.30
Other Costs Total without Interest	69,876.99										
Sum	75,653.52	7,401.62	7,436.10	7,471.27	7,507.14	7,543.73	7,581.06	7,619.12	7,657.95	7,697.56	7,737.96
Costs	563,137.09	54,912.37	55,207.47	55,508.48	55,815.51	56,128.68	56,448.11	56,773.93	57,106.27	57,445.25	57,791.02
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	98,264.99	10,725.00	10,514.71	10,308.54	10,106.41	9,908.24	9,713.96	9,523.49	9,336.76	9,153.68	8,974.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	182,053.77	16,626.34	16,958.87	17,298.04	17,644.00	17,996.88	18,356.82	18,723.96	19,098.44	19,480.41	19,870.01
Sum	368,606.08	36,987.34	36,920.63	36,868.40	36,830.63	36,807.30	36,798.41	36,803.94	36,823.91	36,858.32	36,907.19
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-17,925.03	-18,286.84	-18,640.08	-18,984.88	-19,321.38	-19,649.70	-19,969.99	-20,282.36	-20,586.93	-20,883.83
Return on Investment		-4%	-4%	-4%	-5%	-5%	-5%	-5%	-5%	-5%	-5%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012

Appendix

Variant 1.25-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	688		
Padditional [kWel]	83		
CHP 1 [kWel]	550	6,935	3,814,250
CHP 2 (additional CHP) [kWel]	138	7,300	1,003,750
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	192,268.01	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	11,687.50	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	11,000.00	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59
Investment Total without Interest	344,495.09										
Sum	383,514.42	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System		116.88	119.21	121.60	124.03	126.51	129.04	131.62	134.25	136.94	139.68
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		110.00	112.20	114.44	116.73	119.07	121.45	123.88	126.36	128.88	131.46
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	110,631.10	10,103.55	10,305.63	10,511.74	10,721.97	10,936.41	11,155.14	11,378.24	11,605.81	11,837.92	12,074.68
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	20,996.88	1,917.57	1,955.92	1,995.04	2,034.94	2,075.64	2,117.15	2,159.50	2,202.69	2,246.74	2,291.68
Other Costs Total without Interest	71,996.88										
Sum	77,773.41	7,595.23	7,633.58	7,672.69	7,712.60	7,753.29	7,794.81	7,837.15	7,880.34	7,924.39	7,969.33
Costs	615,402.57	60,021.43	60,341.28	60,667.52	61,000.29	61,339.71	61,685.93	62,039.06	62,399.26	62,766.67	63,141.42
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	98,264.99	10,725.00	10,514.71	10,308.54	10,106.41	9,908.24	9,713.96	9,523.49	9,336.76	9,153.68	8,974.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	132,423.74	12,093.80	12,335.68	12,582.39	12,834.04	13,090.72	13,352.53	13,619.58	13,891.98	14,169.82	14,453.21
Sum	318,976.05	32,454.80	32,297.44	32,152.75	32,020.66	31,901.14	31,794.12	31,699.57	31,617.45	31,547.73	31,490.39
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-27,566.63	-28,043.84	-28,514.77	-28,979.63	-29,438.58	-29,891.81	-30,339.49	-30,781.81	-31,218.93	-31,651.03
Return on Investment		-6%	-6%	-6%	-6%	-6%	-6%	-7%	-7%	-7%	-7%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013

Variant 1.25-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	688		
Padditional [kWel]	83		
CHP 1 [kWel]	550	7,093	3,901,150
CHP 2 (additional CHP) [kWel]	138	6,675	917,813
Total Electricity Production [kWhel/a]	4,818,963		
Additional Earnings Electricity Market [€/kWel; rated a]	28.02		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	192,268.01	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	11,687.50	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	11,000.00	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59
Investment Total without Interest	344,495.09										
Sum	383,514.42	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,706.03	2,760.15	2,815.36	2,871.66	2,929.10	2,987.68	3,047.43	3,108.38	3,170.55	3,233.96
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System		116.88	119.21	121.60	124.03	126.51	129.04	131.62	134.25	136.94	139.68
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		110.00	112.20	114.44	116.73	119.07	121.45	123.88	126.36	128.88	131.46
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	110,637.02	10,104.09	10,306.18	10,512.30	10,722.55	10,937.00	11,155.74	11,378.85	11,606.43	11,838.56	12,075.33
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	20,996.88	1,917.57	1,955.92	1,995.04	2,034.94	2,075.64	2,117.15	2,159.50	2,202.69	2,246.74	2,291.68
Other Costs Total without Interest	71,996.88										
Sum	77,773.41	7,595.23	7,633.58	7,672.69	7,712.60	7,753.29	7,794.81	7,837.15	7,880.34	7,924.39	7,969.33
Costs	615,408.49	60,021.97	60,341.83	60,668.08	61,000.86	61,340.30	61,686.52	62,039.67	62,399.88	62,767.30	63,142.06
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	98,284.62	10,727.14	10,516.81	10,310.59	10,108.43	9,910.22	9,715.90	9,525.40	9,338.62	9,155.51	8,975.99
Application Value 0,002 €/kWh	88,304.95	9,637.93	9,448.95	9,263.67	9,082.03	8,903.95	8,729.37	8,558.20	8,390.39	8,225.88	8,064.58
Additional Market Profits	168,754.20	15,411.74	15,719.97	16,034.37	16,355.06	16,682.16	17,015.80	17,356.12	17,703.24	18,057.30	18,418.45
Sum	355,343.77	35,776.80	35,685.72	35,608.64	35,545.51	35,496.33	35,461.07	35,439.71	35,432.26	35,438.69	35,459.03
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-24,245.17	-24,656.11	-25,059.45	-25,455.35	-25,843.97	-26,225.45	-26,599.96	-26,967.63	-27,328.61	-27,683.04
Return on Investment		-5%	-5%	-5%	-6%	-6%	-6%	-6%	-6%	-6%	-6%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013

Appendix

Variant 1.25-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550	7,012	3,856,600
Installed Capacity [kWel]	688		
Padditional [kWel]	83		
CHP 1 [kWel]	550	6,992	961,400
CHP 2 (additional CHP) [kWel]	138		
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	33.35		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	192,268.01	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53	21,404.53
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	11,687.50	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13	1,301.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	11,000.00	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59	1,224.59
Investment Total without Interest	344,495.09										
Sum	383,514.42	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44	38,351.44
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System		116.88	119.21	121.60	124.03	126.51	129.04	131.62	134.25	136.94	139.68
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		110.00	112.20	114.44	116.73	119.07	121.45	123.88	126.36	128.88	131.46
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	110,631.10	10,103.55	10,305.63	10,511.74	10,721.97	10,936.41	11,155.14	11,378.24	11,605.81	11,837.92	12,074.68
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	20,996.88	1,917.57	1,955.92	1,995.04	2,034.94	2,075.64	2,117.15	2,159.50	2,202.69	2,246.74	2,291.68
Other Costs Total without Interest	71,996.88										
Sum	77,773.41	7,595.23	7,633.58	7,672.69	7,712.60	7,753.29	7,794.81	7,837.15	7,880.34	7,924.39	7,969.33
Costs	615,402.57	60,021.43	60,341.28	60,667.52	61,000.29	61,339.71	61,685.93	62,039.06	62,399.26	62,766.67	63,141.42
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	98,264.99	10,725.00	10,514.71	10,308.54	10,106.41	9,908.24	9,713.96	9,523.49	9,336.76	9,153.68	8,974.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	200,875.32	18,345.25	18,712.15	19,086.39	19,468.12	19,857.48	20,254.63	20,659.73	21,072.92	21,494.38	21,924.27
Sum	387,427.63	38,706.25	38,673.92	38,656.75	38,654.75	38,667.90	38,696.22	38,739.71	38,798.40	38,872.30	38,961.44
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-21,315.19	-21,667.36	-22,010.77	-22,345.54	-22,671.81	-22,989.71	-23,299.35	-23,600.87	-23,894.37	-24,179.98	-24,459.98
Return on Investment		-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013

Variant 1.5-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	825		
Padditional [kWel]	220		
CHP 1 [kWel]	550	6,205	3,412,750
CHP 2 (additional CHP) [kWel]	275	5,110	1,405,250
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	32.18		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	306,974.48	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	23,375.00	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	22,000.00	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18
Investment Total without Interest	366,349.48										
Sum	407,844.16	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		233.75	238.43	243.19	248.06	253.02	258.08	263.24	268.51	273.88	279.35
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		220.00	224.40	228.89	233.47	238.14	242.90	247.76	252.71	257.77	262.92
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	75,161.53	6,864.24	7,001.53	7,141.56	7,284.39	7,430.08	7,578.68	7,730.25	7,884.86	8,042.55	8,203.40
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	22,328.90	2,039.22	2,080.01	2,121.61	2,164.04	2,207.32	2,251.46	2,296.49	2,342.42	2,389.27	2,437.06
Other Costs Total without Interest	73,328.90										
Sum	79,105.43	7,716.87	7,757.66	7,799.26	7,841.69	7,884.97	7,929.12	7,974.15	8,020.08	8,066.93	8,114.71
Costs	605,594.76	59,336.74	59,594.23	59,856.88	60,124.77	60,398.03	60,676.75	60,961.04	61,251.02	61,546.80	61,848.49
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	262,039.97	28,600.00	28,039.22	27,489.43	26,950.42	26,421.98	25,903.90	25,395.98	24,898.02	24,409.82	23,931.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	193,792.59	17,698.40	18,052.37	18,413.42	18,781.69	19,157.32	19,540.47	19,931.28	20,329.90	20,736.50	21,151.23
Sum	544,119.87	55,934.40	55,538.65	55,164.67	54,812.32	54,481.48	54,171.99	53,883.75	53,616.64	53,370.56	53,145.41
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-3,402.34	-4,055.59	-4,692.21	-5,312.45	-5,916.55	-6,504.76	-7,077.29	-7,634.38	-8,176.24	-8,703.09	-9,203.09
Return on Investment		-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.012	0.012	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.013

Appendix

Variant 1.5-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	825		
Padditional [kWel]	220		
CHP 1 [kWel]	550	6,101	3,355,393
CHP 2 (additional CHP) [kWel]	275	5,319	1,462,607
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	35.06		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	306,974.48	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	23,375.00	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	22,000.00	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18
Investment Total without Interest	366,349.48										
Sum	407,844.16	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		233.75	238.43	243.19	248.06	253.02	258.08	263.24	268.51	273.88	279.35
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		220.00	224.40	228.89	233.47	238.14	242.90	247.76	252.71	257.77	262.92
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	75,161.53	6,864.24	7,001.53	7,141.56	7,284.39	7,430.08	7,578.68	7,730.25	7,884.86	8,042.55	8,203.40
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	22,328.90	2,039.22	2,080.01	2,121.61	2,164.04	2,207.32	2,251.46	2,296.49	2,342.42	2,389.27	2,437.06
Other Costs Total without Interest	73,328.90										
Sum	79,105.43	7,716.87	7,757.66	7,799.26	7,841.69	7,884.97	7,929.12	7,974.15	8,020.08	8,066.93	8,114.71
Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
	605,594.76	59,336.74	59,594.23	59,856.88	60,124.77	60,398.03	60,676.75	60,961.04	61,251.02	61,546.80	61,848.49
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	262,039.95	28,600.00	28,039.21	27,489.42	26,950.42	26,421.98	25,903.90	25,395.98	24,898.02	24,409.82	23,931.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	211,161.60	19,284.66	19,670.35	20,063.76	20,465.03	20,874.33	21,291.82	21,717.65	22,152.01	22,595.05	23,046.95
Sum	561,488.85	57,520.65	57,156.62	56,815.00	56,495.66	56,198.48	55,923.34	55,670.13	55,438.74	55,229.10	55,041.12
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-1,816.09	-2,437.61	-3,041.88	-3,629.11	-4,199.55	-4,753.41	-5,290.92	-5,812.28	-6,317.70	-6,807.37
Return on Investment		0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.012	0.012	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.013

Variant 1.5-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	825		
Padditional [kWel]	220		
CHP 1 [kWel]	550	6,085	3,346,750
CHP 2 (additional CHP) [kWel]	275	5,350	1,471,250
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	38.25		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	306,974.48	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Füllstandsüberwachung weiterer Behälter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Conditioning / Gas Pipe System	23,375.00	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	22,000.00	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18
<i>Investment Total without Interest</i>	366,349.48										
Sum	407,844.16	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42	40,784.42
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		233.75	238.43	243.19	248.06	253.02	258.08	263.24	268.51	273.88	279.35
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		220.00	224.40	228.89	233.47	238.14	242.90	247.76	252.71	257.77	262.92
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	75,161.53	6,864.24	7,001.53	7,141.56	7,284.39	7,430.08	7,578.68	7,730.25	7,884.86	8,042.55	8,203.40
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	22,328.90	2,039.22	2,080.01	2,121.61	2,164.04	2,207.32	2,251.46	2,296.49	2,342.42	2,389.27	2,437.06
<i>Other Costs Total without Interest</i>	73,328.90										
Sum	79,105.43	7,716.87	7,757.66	7,799.26	7,841.69	7,884.97	7,929.12	7,974.15	8,020.08	8,066.93	8,114.71
Costs	605,594.76	59,336.74	59,594.23	59,856.88	60,124.77	60,398.03	60,676.75	60,961.04	61,251.02	61,546.80	61,848.49
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	262,039.97	28,600.00	28,039.22	27,489.43	26,950.42	26,421.98	25,903.90	25,395.98	24,898.02	24,409.82	23,931.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	230,354.76	21,037.50	21,458.25	21,887.42	22,325.16	22,771.67	23,227.10	23,691.64	24,165.47	24,648.78	25,141.76
Sum	580,682.04	59,273.50	58,944.52	58,638.66	58,355.80	58,095.82	57,858.62	57,644.12	57,452.21	57,282.84	57,135.93
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-63.24	-649.71	-1,218.21	-1,768.97	-2,302.21	-2,818.12	-3,316.93	-3,798.81	-4,263.96	-4,712.56	-5,154.16
Return on Investment		0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%	-1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.012	0.012	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.013

Appendix

Variant 1.5-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	825		
Padditional [kWel]	220		
CHP 1 [kWel]	550	5,840	3,212,000
CHP 2 (additional CHP) [kWel]	275	5,475	1,505,625
Total Electricity Production [kWhel/a]	4,717,625		
Additional Earnings Electricity Market [€/kWel; rated a]	32.53		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	306,974.48	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	23,375.00	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	22,000.00	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18
<i>Investment Total without Interest</i>	447,108.17										
Sum	497,750.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,649.13	2,702.11	2,756.15	2,811.28	2,867.50	2,924.85	2,983.35	3,043.01	3,103.87	3,165.95
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System		233.75	238.43	243.19	248.06	253.02	258.08	263.24	268.51	273.88	279.35
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		220.00	224.40	228.89	233.47	238.14	242.90	247.76	252.71	257.77	262.92
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	101,072.91	9,230.64	9,415.25	9,603.56	9,795.63	9,991.54	10,191.37	10,395.20	10,603.10	10,815.16	11,031.47
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	27,251.12	2,488.75	2,538.53	2,589.30	2,641.08	2,693.90	2,747.78	2,802.74	2,858.79	2,915.97	2,974.29
<i>Other Costs Total without Interest</i>	78,251.12										
Sum	84,027.65	8,166.40	8,216.18	8,266.95	8,318.73	8,371.56	8,425.43	8,480.39	8,536.44	8,593.62	8,651.94
Costs	726,334.20	71,143.25	71,457.06	71,777.15	72,103.64	72,436.66	72,776.34	73,122.81	73,476.22	73,836.69	74,204.37
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	256,580.80	28,004.17	27,455.07	26,916.73	26,388.95	25,871.52	25,364.24	24,866.90	24,379.31	23,901.29	23,432.63
Application Value 0,002 €/kWh	86,447.99	9,435.25	9,250.25	9,068.87	8,891.05	8,716.71	8,545.80	8,378.23	8,213.95	8,052.90	7,895.00
Additional Market Profits	195,898.33	17,890.71	18,248.53	18,613.50	18,985.77	19,365.48	19,752.79	20,147.85	20,550.81	20,961.82	21,381.06
Sum	538,927.13	55,330.13	54,953.84	54,599.10	54,265.77	53,953.72	53,662.83	53,392.98	53,144.07	52,916.00	52,708.69
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-15,813.12	-16,503.22	-17,178.05	-17,837.87	-18,482.94	-19,113.51	-19,729.83	-20,332.15	-20,920.68	-21,495.68
Return on Investment		-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.016	0.016	0.016

Variant 1.5-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	825		
Padditional [kWel]	220		
CHP 1 [kWel]	550	5,892	3,240,677
CHP 2 (additional CHP) [kWel]	275	5,736	1,577,320
Total Electricity Production [kWhel/a]	4,817,997		
Additional Earnings Electricity Market [€/kWel; rated a]	41.68		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	306,974.48	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	23,375.00	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	22,000.00	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18
Investment Total without Interest	447,108.17										
Sum	497,750.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System		233.75	238.43	243.19	248.06	253.02	258.08	263.24	268.51	273.88	279.35
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		220.00	224.40	228.89	233.47	238.14	242.90	247.76	252.71	257.77	262.92
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	101,690.07	9,287.00	9,472.74	9,662.20	9,855.44	10,052.55	10,253.60	10,458.67	10,667.84	10,881.20	11,098.83
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	27,251.12	2,488.75	2,538.53	2,589.30	2,641.08	2,693.90	2,747.78	2,802.74	2,858.79	2,915.97	2,974.29
Other Costs Total without Interest	78,251.12										
Sum	84,027.65	8,166.40	8,216.18	8,266.95	8,318.73	8,371.56	8,425.43	8,480.39	8,536.44	8,593.62	8,651.94
Costs	726,951.36	71,199.61	71,514.55	71,835.79	72,163.45	72,497.67	72,838.57	73,186.29	73,540.96	73,902.73	74,271.73
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	262,039.82	28,599.98	28,039.20	27,489.41	26,950.40	26,421.96	25,903.89	25,395.97	24,898.01	24,409.81	23,931.19
Application Value 0,002 €/kWh	88,287.26	9,635.99	9,447.05	9,261.82	9,080.21	8,902.17	8,727.62	8,556.49	8,388.71	8,224.23	8,062.97
Additional Market Profits	251,026.71	22,925.40	23,383.91	23,851.58	24,328.62	24,815.19	25,311.49	25,817.72	26,334.08	26,860.76	27,397.97
Sum	601,353.79	61,161.38	60,870.16	60,602.81	60,359.23	60,139.32	59,942.99	59,770.18	59,620.80	59,494.80	59,392.13
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-10,038.24	-10,644.39	-11,232.98	-11,804.22	-12,358.35	-12,895.58	-13,416.11	-13,920.17	-14,407.93	-14,879.60
Return on Investment		-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015

Appendix

Variant 1.5-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	825		
Padditional [kWel]	220		
CHP 1 [kWel]	550	5,890	3,239,500
CHP 2 (additional CHP) [kWel]	275	5,740	1,578,500
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	45,90		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	306,974.48	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	23,375.00	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	22,000.00	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18
<i>Investment Total without Interest</i>	447,108.17										
Sum	497,750.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00	49,775.00
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System		233.75	238.43	243.19	248.06	253.02	258.08	263.24	268.51	273.88	279.35
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		220.00	224.40	228.89	233.47	238.14	242.90	247.76	252.71	257.77	262.92
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	101,690.09	9,287.00	9,472.74	9,662.20	9,855.44	10,052.55	10,253.60	10,458.67	10,667.85	10,881.20	11,098.83
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	27,251.12	2,488.75	2,538.53	2,589.30	2,641.08	2,693.90	2,747.78	2,802.74	2,858.79	2,915.97	2,974.29
<i>Other Costs Total without Interest</i>	78,251.12										
Sum	84,027.65	8,166.40	8,216.18	8,266.95	8,318.73	8,371.56	8,425.43	8,480.39	8,536.44	8,593.62	8,651.94
Costs	726,951.38	71,199.62	71,514.55	71,835.79	72,163.46	72,497.67	72,838.57	73,186.29	73,540.96	73,902.73	74,271.73
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	262,039.97	28,600.00	28,039.22	27,489.43	26,950.42	26,421.98	25,903.90	25,395.98	24,898.02	24,409.82	23,931.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	276,414.08	25,243.94	25,748.82	26,263.79	26,789.07	27,324.85	27,871.35	28,428.77	28,997.35	29,577.30	30,168.84
Sum	626,741.37	63,479.94	63,235.09	63,015.04	62,819.71	62,649.00	62,502.87	62,381.25	62,284.09	62,211.36	62,163.02
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-7,719.68	-8,279.46	-8,820.75	-9,343.75	-9,848.67	-10,335.70	-10,805.04	-11,256.87	-11,691.37	-12,108.71
Return on Investment		-1%	-1%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015	0.015

Variant 1.5-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	825		
Padditional [kWel]	220		
CHP 1 [kWel]	550	5,840	3,212,000
CHP 2 (additional CHP) [kWel]	275	5,475	1,505,625
Total Electricity Production [kWhel/a]	4,717,625		
Additional Earnings Electricity Market [€/kWel; rated a]	32.53		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	306,974.48	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	23,375.00	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	22,000.00	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18
Investment Total without Interest	481,889.06										
Sum	536,470.36	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,649.13	2,702.11	2,756.15	2,811.28	2,867.50	2,924.85	2,983.35	3,043.01	3,103.87	3,165.95
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System		233.75	238.43	243.19	248.06	253.02	258.08	263.24	268.51	273.88	279.35
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		220.00	224.40	228.89	233.47	238.14	242.90	247.76	252.71	257.77	262.92
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	112,498.14	10,274.06	10,479.55	10,689.14	10,902.92	11,120.98	11,343.40	11,570.27	11,801.67	12,037.70	12,278.46
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	29,371.00	2,682.35	2,736.00	2,790.72	2,846.53	2,903.46	2,961.53	3,020.76	3,081.18	3,142.80	3,205.66
Other Costs Total without Interest	80,371.00										
Sum	86,147.53	8,360.00	8,413.65	8,468.37	8,524.19	8,581.12	8,639.19	8,698.42	8,758.83	8,820.46	8,883.31
Costs	778,599.68	76,252.32	76,590.87	76,936.19	77,288.42	77,647.70	78,014.16	78,387.95	78,769.21	79,158.10	79,554.77
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	256,580.80	28,004.17	27,455.07	26,916.73	26,388.95	25,871.52	25,364.24	24,866.90	24,379.31	23,901.29	23,432.63
Application Value 0,002 €/kWh	86,447.99	9,435.25	9,250.25	9,068.87	8,891.05	8,716.71	8,545.80	8,378.23	8,213.95	8,052.90	7,895.00
Additional Market Profits	195,898.33	17,890.71	18,248.53	18,613.50	18,985.77	19,365.48	19,752.79	20,147.85	20,550.81	20,961.82	21,381.06
Sum	538,927.13	55,330.13	54,953.84	54,599.10	54,265.77	53,953.72	53,662.83	53,392.98	53,144.07	52,916.00	52,708.69
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-20,922.18	-21,637.03	-22,337.09	-23,022.65	-23,693.98	-24,351.33	-24,994.97	-25,625.14	-26,242.10	-26,846.08	-27,438.69
Return on Investment		-3%	-3%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.016	0.016	0.016	0.016	0.016	0.017	0.017	0.017	0.017	0.017

Appendix

Variant 1.5-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	825		
Padditional [kWel]	220		
CHP 1 [kWel]	550	5,892	3,240,677
CHP 2 (additional CHP) [kWel]	275	5,736	1,577,320
Total Electricity Production [kWhel/a]	4,817,997		
Additional Earnings Electricity Market [€/kWel; rated a]	45.61		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	306,974.48	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	23,375.00	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	22,000.00	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18
<i>Investment Total without Interest</i>	481,889.06										
Sum	536,470.36	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System		233.75	238.43	243.19	248.06	253.02	258.08	263.24	268.51	273.88	279.35
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		220.00	224.40	228.89	233.47	238.14	242.90	247.76	252.71	257.77	262.92
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	113,115.30	10,330.43	10,537.04	10,747.78	10,962.73	11,181.99	11,405.63	11,633.74	11,866.41	12,103.74	12,345.82
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	29,371.00	2,682.35	2,736.00	2,790.72	2,846.53	2,903.46	2,961.53	3,020.76	3,081.18	3,142.80	3,205.66
<i>Other Costs Total without Interest</i>	80,371.00										
Sum	86,147.53	8,360.00	8,413.65	8,468.37	8,524.19	8,581.12	8,639.19	8,698.42	8,758.83	8,820.46	8,883.31
Costs	779,216.84	76,308.68	76,648.36	76,994.83	77,348.23	77,708.71	78,076.39	78,451.42	78,833.95	79,224.14	79,622.13
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	262,039.82	28,599.98	28,039.20	27,489.41	26,950.40	26,421.96	25,903.89	25,395.97	24,898.01	24,409.81	23,931.19
Application Value 0,002 €/kWh	88,287.26	9,635.99	9,447.05	9,261.82	9,080.21	8,902.17	8,727.62	8,556.49	8,388.71	8,224.23	8,062.97
Additional Market Profits	274,661.53	25,083.88	25,585.56	26,097.27	26,619.22	27,151.60	27,694.64	28,248.53	28,813.50	29,389.77	29,977.56
Sum	624,988.62	63,319.86	63,071.82	62,848.50	62,649.83	62,475.74	62,326.14	62,200.98	62,100.22	62,023.81	61,971.72
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-12,988.82	-13,576.54	-14,146.33	-14,698.40	-15,232.97	-15,750.25	-16,250.44	-16,733.74	-17,200.33	-17,650.41
Return on Investment		-2%	-2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.017

Variant 1.5-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	825		
Padditional [kWel]	220		
CHP 1 [kWel]	550	5,861	3,223,550
CHP 2 (additional CHP) [kWel]	275	5,798	1,594,450
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	50.17		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	306,974.48	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40	34,174.40
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	23,375.00	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26	2,602.26
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	22,000.00	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18	2,449.18
Investment Total without Interest	481,889.06										
Sum	536,470.36	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04	53,647.04
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System		233.75	238.43	243.19	248.06	253.02	258.08	263.24	268.51	273.88	279.35
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		220.00	224.40	228.89	233.47	238.14	242.90	247.76	252.71	257.77	262.92
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	113,115.32	10,330.43	10,537.04	10,747.78	10,962.73	11,181.99	11,405.63	11,633.74	11,866.42	12,103.74	12,345.82
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	29,371.00	2,682.35	2,736.00	2,790.72	2,846.53	2,903.46	2,961.53	3,020.76	3,081.18	3,142.80	3,205.66
Other Costs Total without Interest	80,371.00										
Sum	86,147.53	8,360.00	8,413.65	8,468.37	8,524.19	8,581.12	8,639.19	8,698.42	8,758.83	8,820.46	8,883.31
Costs	779,216.85	76,308.68	76,648.36	76,994.83	77,348.24	77,708.71	78,076.39	78,451.42	78,833.96	79,224.14	79,622.13
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	262,039.97	28,600.00	28,039.22	27,489.43	26,950.42	26,421.98	25,903.90	25,395.98	24,898.02	24,409.82	23,931.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	302,142.18	27,593.60	28,145.47	28,708.38	29,282.55	29,868.20	30,465.56	31,074.87	31,696.37	32,330.30	32,976.90
Sum	652,469.46	65,829.60	65,631.74	65,459.63	65,313.18	65,192.35	65,097.08	65,027.34	64,983.11	64,964.35	64,971.08
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-10,479.08	-11,016.62	-11,535.21	-12,035.05	-12,516.36	-12,979.30	-13,424.08	-13,850.85	-14,259.79	-14,651.05
Return on Investment		-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.017

Appendix

Variant 2-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,100		
Padditional [kWel]	495		
CHP 1 [kWel]	550	4,015	2,208,250
CHP 2 (additional CHP) [kWel]	550	4,745	2,609,750
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	43.56		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	490,114.47	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	46,750.00	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	44,000.00	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37
Investment Total without Interest	594,864.47										
Sum	662,241.96	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		467.50	476.85	486.39	496.11	506.04	516.16	526.48	537.01	547.75	558.71
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		440.00	448.80	457.78	466.93	476.27	485.80	495.51	505.42	515.53	525.84
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	80,129.97	7,317.99	7,464.35	7,613.64	7,765.91	7,921.23	8,079.65	8,241.25	8,406.07	8,574.19	8,745.68
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	36,256.82	3,311.21	3,377.43	3,444.98	3,513.88	3,584.16	3,655.84	3,728.96	3,803.54	3,879.61	3,957.20
Other Costs Total without Interest	87,256.82										
Sum	93,033.35	8,988.86	9,055.09	9,122.64	9,191.54	9,261.81	9,333.50	9,406.61	9,481.19	9,557.26	9,634.86
Costs		878,888.92	86,502.26	86,794.27	87,092.12	87,395.92	87,705.80	88,021.88	88,344.28	88,673.13	89,008.56
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	589,589.93	64,350.00	63,088.24	61,851.21	60,638.44	59,449.45	58,283.78	57,140.96	56,020.55	54,922.11	53,845.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	262,313.61	23,956.19	24,435.32	24,924.02	25,422.50	25,930.95	26,449.57	26,978.56	27,518.13	28,068.50	28,629.87
Sum	940,190.85	97,942.19	96,970.61	96,037.05	95,141.16	94,282.58	93,460.97	92,676.01	91,927.40	91,214.83	90,538.04
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		11,439.93	10,176.34	8,944.94	7,745.24	6,576.78	5,439.09	4,331.73	3,254.27	2,206.28	1,187.35
Return on Investment		2%	1%	1%	1%	1%	1%	1%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.019

Variant 2-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,100		
Padditional [kWel]	495		
CHP 1 [kWel]	550	3,651	2,008,050
CHP 2 (additional CHP) [kWel]	550	5,110	2,810,500
Total Electricity Production [kWhel/a]	4,818,550		
Additional Earnings Electricity Market [€/kWel; rated a]	46.65		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	490,114.47	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	46,750.00	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	44,000.00	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37
Investment Total without Interest	594,864.47										
Sum	662,241.96	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.80	2,759.92	2,815.12	2,871.42	2,928.85	2,987.42	3,047.17	3,108.11	3,170.28	3,233.68
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		467.50	476.85	486.39	496.11	506.04	516.16	526.48	537.01	547.75	558.71
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		440.00	448.80	457.78	466.93	476.27	485.80	495.51	505.42	515.53	525.84
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	80,133.35	7,318.30	7,464.67	7,613.96	7,766.24	7,921.56	8,080.00	8,241.60	8,406.43	8,574.56	8,746.05
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	36,256.82	3,311.21	3,377.43	3,444.98	3,513.88	3,584.16	3,655.84	3,728.96	3,803.54	3,879.61	3,957.20
Other Costs Total without Interest	87,256.82										
Sum	93,033.35	8,988.86	9,055.09	9,122.64	9,191.54	9,261.81	9,333.50	9,406.61	9,481.19	9,557.26	9,634.86
Costs	878,892.30	86,502.57	86,794.58	87,092.44	87,396.25	87,706.14	88,022.22	88,344.63	88,673.49	89,008.92	89,351.06
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	589,657.24	64,357.35	63,095.44	61,858.27	60,645.36	59,456.24	58,290.43	57,147.48	56,026.94	54,928.38	53,851.35
Application Value 0,002 €/kWh	88,297.39	9,637.10	9,448.14	9,262.88	9,081.25	8,903.19	8,728.62	8,557.47	8,389.68	8,225.17	8,063.89
Additional Market Profits	280,963.76	25,659.44	26,172.63	26,696.09	27,230.01	27,774.61	28,330.10	28,896.70	29,474.64	30,064.13	30,665.41
Sum	958,918.38	99,653.89	98,716.21	97,817.24	96,956.63	96,134.04	95,349.15	94,601.65	93,891.25	93,217.68	92,580.65
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		13,151.32	11,921.62	10,724.80	9,560.38	8,427.90	7,326.93	6,257.02	5,217.77	4,208.76	3,229.59
Return on Investment		2%	2%	1%	1%	1%	1%	1%	1%	1%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.019

Appendix

Variant 2-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,100		
Padditional [kWel]	495		
CHP 1 [kWel]	550	3,650	2,007,500
CHP 2 (additional CHP) [kWel]	550	5,110	2,810,500
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	52.42		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	490,114.47	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	46,750.00	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	44,000.00	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37
Investment Total without Interest	594,864.47										
Sum	662,241.96	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20	66,224.20
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		467.50	476.85	486.39	496.11	506.04	516.16	526.48	537.01	547.75	558.71
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		440.00	448.80	457.78	466.93	476.27	485.80	495.51	505.42	515.53	525.84
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	80,129.97	7,317.99	7,464.35	7,613.64	7,765.91	7,921.23	8,079.65	8,241.25	8,406.07	8,574.19	8,745.68
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	36,256.82	3,311.21	3,377.43	3,444.98	3,513.88	3,584.16	3,655.84	3,728.96	3,803.54	3,879.61	3,957.20
Other Costs Total without Interest	87,256.82										
Sum	93,033.35	8,988.86	9,055.09	9,122.64	9,191.54	9,261.81	9,333.50	9,406.61	9,481.19	9,557.26	9,634.86
Costs		878,888.92	86,502.26	86,794.27	87,092.12	87,395.92	87,705.80	88,021.88	88,344.28	88,673.13	89,008.56
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	589,589.93	64,350.00	63,088.24	61,851.21	60,638.44	59,449.45	58,283.78	57,140.96	56,020.55	54,922.11	53,845.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	315,704.82	28,832.22	29,408.87	29,997.05	30,596.99	31,208.93	31,833.11	32,469.77	33,119.16	33,781.55	34,457.18
Sum	993,582.06	102,818.22	101,944.16	101,110.08	100,315.65	99,560.56	98,844.51	98,167.22	97,528.43	96,927.89	96,365.35
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		16,315.96	15,149.89	14,017.96	12,919.73	11,854.75	10,822.62	9,822.94	8,855.30	7,919.33	7,014.66
Return on Investment		2%	2%	2%	2%	2%	1%	1%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.019

Variant 2-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,100		
Padditional [kWel]	495		
CHP 1 [kWel]	550	4,380	2,409,000
CHP 2 (additional CHP) [kWel]	550	4,380	2,409,000
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	44.92		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	490,114.47	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	46,750.00	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	44,000.00	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37
Investment Total without Interest	675,623.16										
Sum	752,147.81	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System		467.50	476.85	486.39	496.11	506.04	516.16	526.48	537.01	547.75	558.71
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		440.00	448.80	457.78	466.93	476.27	485.80	495.51	505.42	515.53	525.84
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	106,658.52	9,740.75	9,935.57	10,134.28	10,336.96	10,543.70	10,754.58	10,969.67	11,189.06	11,412.84	11,641.10
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	41,179.04	3,760.74	3,835.95	3,912.67	3,990.93	4,070.74	4,152.16	4,235.20	4,319.91	4,406.31	4,494.43
Other Costs Total without Interest	92,179.04										
Sum	97,955.57	9,438.39	9,513.61	9,590.33	9,668.58	9,748.40	9,829.81	9,912.86	9,997.56	10,083.96	10,172.08
Costs	1,000,245.54	98,365.13	98,714.59	99,071.03	99,434.60	99,805.45	100,183.71	100,569.53	100,963.07	101,364.49	101,773.93
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	589,589.93	64,350.00	63,088.24	61,851.21	60,638.44	59,449.45	58,283.78	57,140.96	56,020.55	54,922.11	53,845.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	270,501.77	24,703.99	25,198.07	25,702.03	26,216.07	26,740.39	27,275.20	27,820.70	28,377.12	28,944.66	29,523.55
Sum	948,379.02	98,689.99	97,733.36	96,815.06	95,934.73	95,092.02	94,286.60	93,518.15	92,786.38	92,091.00	91,431.73
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	324.85	-981.23	-2,255.97	-3,499.87	-4,713.43	-5,897.11	-7,051.38	-8,176.69	-9,273.49	-10,342.20	-11,384.20
Return on Investment		0%	0%	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021

Appendix

Variant 2-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,100		
Padditional [kWel]	495		
CHP 1 [kWel]	550	4,068	2,237,400
CHP 2 (additional CHP) [kWel]	550	4,693	2,581,150
Total Electricity Production [kWhel/a]	4,818,550		
Additional Earnings Electricity Market [€/kWel; rated a]	54.60		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	490,114.47	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	46,750.00	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	44,000.00	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37
<i>Investment Total without Interest</i>	675,623.16										
Sum	752,147.81	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.80	2,759.92	2,815.12	2,871.42	2,928.85	2,987.42	3,047.17	3,108.11	3,170.28	3,233.68
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System		467.50	476.85	486.39	496.11	506.04	516.16	526.48	537.01	547.75	558.71
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		440.00	448.80	457.78	466.93	476.27	485.80	495.51	505.42	515.53	525.84
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	106,661.90	9,741.06	9,935.88	10,134.60	10,337.29	10,544.04	10,754.92	10,970.02	11,189.42	11,413.21	11,641.47
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	41,179.04	3,760.74	3,835.95	3,912.67	3,990.93	4,070.74	4,152.16	4,235.20	4,319.91	4,406.31	4,494.43
<i>Other Costs Total without Interest</i>	92,179.04										
Sum	97,955.57	9,438.39	9,513.61	9,590.33	9,668.58	9,748.40	9,829.81	9,912.86	9,997.56	10,083.96	10,172.08
Costs	1,000,248.92	98,365.44	98,714.90	99,071.35	99,434.93	99,805.78	100,184.05	100,569.88	100,963.43	101,364.85	101,774.30
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	589,657.24	64,357.35	63,095.44	61,858.27	60,645.36	59,456.24	58,290.43	57,147.48	56,026.94	54,928.38	53,851.35
Application Value 0,002 €/kWh	88,297.39	9,637.10	9,448.14	9,262.88	9,081.25	8,903.19	8,728.62	8,557.47	8,389.68	8,225.17	8,063.89
Additional Market Profits	328,822.35	30,030.20	30,630.81	31,243.42	31,868.29	32,505.66	33,155.77	33,818.89	34,495.26	35,185.17	35,888.87
Sum	1,006,776.98	104,024.65	103,174.38	102,364.58	101,594.91	100,865.09	100,174.82	99,523.84	98,911.88	98,338.72	97,804.12
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		5,659.21	4,459.48	3,293.22	2,159.98	1,059.31	-9.23	-1,046.04	-2,051.55	-3,026.13	-3,970.18
Return on Investment		1%	1%	0%	0%	0%	0%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021

Variant 2-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,100		
Padditional [kWel]	495		
CHP 1 [kWel]	550	4,146	2,280,300
CHP 2 (additional CHP) [kWel]	550	4,614	2,537,700
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	63.57		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	490,114.47	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	46,750.00	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	44,000.00	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37
Investment Total without Interest	675,623.16										
Sum	752,147.81	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78	75,214.78
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System		467.50	476.85	486.39	496.11	506.04	516.16	526.48	537.01	547.75	558.71
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		440.00	448.80	457.78	466.93	476.27	485.80	495.51	505.42	515.53	525.84
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	106,658.52	9,740.75	9,935.57	10,134.28	10,336.96	10,543.70	10,754.58	10,969.67	11,189.06	11,412.84	11,641.10
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	41,179.04	3,760.74	3,835.95	3,912.67	3,990.93	4,070.74	4,152.16	4,235.20	4,319.91	4,406.31	4,494.43
Other Costs Total without Interest	92,179.04										
Sum	97,955.57	9,438.39	9,513.61	9,590.33	9,668.58	9,748.40	9,829.81	9,912.86	9,997.56	10,083.96	10,172.08
Costs	1,000,245.54	98,365.13	98,714.59	99,071.03	99,434.60	99,805.45	100,183.71	100,569.53	100,963.07	101,364.49	101,773.93
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	589,589.93	64,350.00	63,088.24	61,851.21	60,638.44	59,449.45	58,283.78	57,140.96	56,020.55	54,922.11	53,845.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	382,815.10	34,961.17	35,660.40	36,373.60	37,101.08	37,843.10	38,599.96	39,371.96	40,159.40	40,962.59	41,781.84
Sum	1,060,692.34	108,947.17	108,195.69	107,486.64	106,819.74	106,194.73	105,611.36	105,069.41	104,568.66	104,108.93	103,690.01
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	10,582.04	9,481.10	8,415.61	7,385.13	6,389.28	5,427.65	4,499.88	3,605.59	2,744.44	1,916.08	1,116.08
Return on Investment		1%	1%	1%	1%	1%	1%	1%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.020	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021

Appendix

Variant 2-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550	4,380	2,409,000
Installed Capacity [kWel]	1,100		
Padditional [kWel]	495		
CHP 1 [kWel]	550	4,380	2,409,000
CHP 2 (additional CHP) [kWel]	550	4,380	2,409,000
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	44.92		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	490,114.47	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Control System	46,750.00	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52
Transformer / Grid	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
#BEZUG!	44,000.00	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37
Sum	710,404.05										
Supply Costs	790,868.16	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System		467.50	476.85	486.39	496.11	506.04	516.16	526.48	537.01	547.75	558.71
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		440.00	448.80	457.78	466.93	476.27	485.80	495.51	505.42	515.53	525.84
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	118,083.75	10,784.18	10,999.86	11,219.86	11,444.26	11,673.14	11,906.61	12,144.74	12,387.63	12,635.38	12,888.09
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	43,298.93	3,954.34	4,033.43	4,114.10	4,196.38	4,280.31	4,365.91	4,453.23	4,542.29	4,633.14	4,725.80
Other Costs Total without Interest	94,298.93										
Sum	100,075.46	9,631.99	9,711.08	9,791.75	9,874.03	9,957.96	10,043.56	10,130.88	10,219.95	10,310.79	10,403.46
Costs	1,052,511.01	103,474.20	103,848.39	104,230.07	104,619.38	105,016.48	105,421.52	105,834.66	106,256.07	106,685.90	107,124.33
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	589,589.93	64,350.00	63,088.24	61,851.21	60,638.44	59,449.45	58,283.78	57,140.96	56,020.55	54,922.11	53,845.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	270,501.77	24,703.99	25,198.07	25,702.03	26,216.07	26,740.39	27,275.20	27,820.70	28,377.12	28,944.66	29,523.55
Sum	948,379.02	98,689.99	97,733.36	96,815.06	95,934.73	95,092.02	94,286.60	93,518.15	92,786.38	92,091.00	91,431.73
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-4,784.21	-6,115.03	-7,415.01	-8,684.65	-9,924.46	-11,134.92	-12,316.51	-13,469.69	-14,594.90	-15,692.60
Return on Investment		-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%	-2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022

Variant 2-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,100		
Padditional [kWel]	495		
CHP 1 [kWel]	550	4,225	2,323,750
CHP 2 (additional CHP) [kWel]	550	4,537	2,495,350
Total Electricity Production [kWhel/a]	4,819,100		
Additional Earnings Electricity Market [€/kWel; rated a]	62.06		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	490,114.47	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	46,750.00	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	44,000.00	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37
Investment Total without Interest	710,404.05										
Sum	790,868.16	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,706.11	2,760.23	2,815.44	2,871.75	2,929.18	2,987.76	3,047.52	3,108.47	3,170.64	3,234.05
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System		467.50	476.85	486.39	496.11	506.04	516.16	526.48	537.01	547.75	558.71
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		440.00	448.80	457.78	466.93	476.27	485.80	495.51	505.42	515.53	525.84
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	118,090.52	10,784.80	11,000.49	11,220.50	11,444.91	11,673.81	11,907.29	12,145.43	12,388.34	12,636.11	12,888.83
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	43,298.93	3,954.34	4,033.43	4,114.10	4,196.38	4,280.31	4,365.91	4,453.23	4,542.29	4,633.14	4,725.80
Other Costs Total without Interest	94,298.93										
Sum	100,075.46	9,631.99	9,711.08	9,791.75	9,874.03	9,957.96	10,043.56	10,130.88	10,219.95	10,310.79	10,403.46
Costs	1,052,517.78	103,474.82	103,849.02	104,230.71	104,620.04	105,017.15	105,422.20	105,835.36	106,256.78	106,686.62	107,125.07
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	589,724.54	64,364.69	63,102.64	61,865.33	60,652.29	59,463.03	58,297.08	57,154.00	56,033.34	54,934.64	53,857.49
Application Value 0,002 €/kWh	88,307.47	9,638.20	9,449.22	9,263.94	9,082.29	8,904.21	8,729.61	8,558.45	8,390.63	8,226.11	8,064.81
Additional Market Profits	373,740.22	34,132.40	34,815.04	35,511.35	36,221.57	36,946.00	37,684.92	38,438.62	39,207.40	39,991.54	40,791.37
Sum	1,051,772.23	108,135.29	107,366.90	106,640.62	105,956.15	105,313.24	104,711.62	104,151.07	103,631.37	103,152.30	102,713.68
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		4,660.47	3,517.88	2,409.90	1,336.11	296.09	-710.58	-1,684.29	-2,625.41	-3,534.32	-4,411.38
Return on Investment		1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022

Appendix

Variant 2-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,100		
Padditional [kWel]	495		
CHP 1 [kWel]	550	4,275	2,351,250
CHP 2 (additional CHP) [kWel]	550	4,485	2,466,750
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	71.98		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	490,114.47	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74	54,562.74
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	46,750.00	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52	5,204.52
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	44,000.00	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37	4,898.37
<i>Investment Total without Interest</i>	710,404.05										
Sum	790,868.16	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82	79,086.82
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System		467.50	476.85	486.39	496.11	506.04	516.16	526.48	537.01	547.75	558.71
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		440.00	448.80	457.78	466.93	476.27	485.80	495.51	505.42	515.53	525.84
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	118,083.75	10,784.18	10,999.86	11,219.86	11,444.26	11,673.14	11,906.61	12,144.74	12,387.63	12,635.38	12,888.09
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	43,298.93	3,954.34	4,033.43	4,114.10	4,196.38	4,280.31	4,365.91	4,453.23	4,542.29	4,633.14	4,725.80
<i>Other Costs Total without Interest</i>	94,298.93										
Sum	100,075.46	9,631.99	9,711.08	9,791.75	9,874.03	9,957.96	10,043.56	10,130.88	10,219.95	10,310.79	10,403.46
Costs	1,052,511.01	103,474.20	103,848.39	104,230.07	104,619.38	105,016.48	105,421.52	105,834.66	106,256.07	106,685.90	107,124.33
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	589,589.93	64,350.00	63,088.24	61,851.21	60,638.44	59,449.45	58,283.78	57,140.96	56,020.55	54,922.11	53,845.20
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	433,502.36	39,590.27	40,382.07	41,189.71	42,013.51	42,853.78	43,710.85	44,585.07	45,476.77	46,386.31	47,314.03
Sum	1,111,379.60	113,576.27	112,917.36	112,302.75	111,732.17	111,205.40	110,722.25	110,282.52	109,886.04	109,532.64	109,222.21
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	10,102.07	9,068.97	8,072.67	7,112.78	6,188.92	5,300.73	4,447.86	3,629.97	2,846.74	2,097.88	1,350.00
Return on Investment		1%	1%	1%	1%	1%	1%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.021	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022	0.022

Variant 3-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,650		
Padditional [kWel]	1,045		
CHP 1 [kWel]	550	4,380	2,409,000
CHP 2 (additional CHP) [kWel]	1,100	2,190	2,409,000
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	52.64		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	782,515.18	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	93,500.00	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	88,000.00	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73
Investment Total without Interest	978,015.18										
Sum	1,088,790.35	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		935.00	953.70	972.77	992.23	1,012.07	1,032.32	1,052.96	1,074.02	1,095.50	1,117.41
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		880.00	897.60	915.55	933.86	952.54	971.59	991.02	1,010.84	1,031.06	1,051.68
Amount of Work			3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90
Sum	90,066.84	8,225.49	8,390.00	8,557.80	8,728.96	8,903.54	9,081.61	9,263.24	9,448.50	9,637.47	9,830.22
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	59,609.75	5,443.95	5,552.83	5,663.89	5,777.17	5,892.71	6,010.56	6,130.77	6,253.39	6,378.46	6,506.03
Other Costs Total without Interest	110,609.75										
Sum	116,386.28	11,121.60	11,230.48	11,341.54	11,454.82	11,570.36	11,688.22	11,808.43	11,931.04	12,056.11	12,183.68
Costs	1,338,727.11	132,197.34	132,550.15	132,910.02	133,277.09	133,651.50	134,033.39	134,422.93	134,820.25	135,225.52	135,638.90
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	982,649.89	107,250.00	105,147.06	103,085.35	101,064.07	99,082.42	97,139.63	95,234.93	93,367.58	91,536.84	89,742.00
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	317,013.50	28,951.74	29,530.78	30,121.39	30,723.82	31,338.30	31,965.06	32,604.36	33,256.45	33,921.58	34,600.01
Sum	1,387,950.70	145,837.74	144,124.89	142,468.57	140,868.11	139,322.89	137,832.31	136,395.79	135,012.75	133,682.66	132,404.99
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		13,640.40	11,574.74	9,558.54	7,591.02	5,671.40	3,798.92	1,972.86	192.50	-1,542.87	-3,233.91
Return on Investment		1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.027	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028

Appendix

Variant 3-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,650		
Padditional [kWel]	1,045		
CHP 1 [kWel]	550	4,277	2,352,350
CHP 2 (additional CHP) [kWel]	1,100	2,242	2,466,200
Total Electricity Production [kWhel/a]	4,818,550		
Additional Earnings Electricity Market [€/kWel; rated a]	56.84		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	782,515.18	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	93,500.00	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	88,000.00	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73
<i>Investment Total without Interest</i>	<i>978,015.18</i>										
Sum	1,088,790.35	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.80	2,759.92	2,815.12	2,871.42	2,928.85	2,987.42	3,047.17	3,108.11	3,170.28	3,233.68
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		935.00	953.70	972.77	992.23	1,012.07	1,032.32	1,052.96	1,074.02	1,095.50	1,117.41
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		880.00	897.60	915.55	933.86	952.54	971.59	991.02	1,010.84	1,031.06	1,051.68
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	90,070.22	8,225.80	8,390.32	8,558.12	8,729.29	8,903.87	9,081.95	9,263.59	9,448.86	9,637.84	9,830.59
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	59,609.75	5,443.95	5,552.83	5,663.89	5,777.17	5,892.71	6,010.56	6,130.77	6,253.39	6,378.46	6,506.03
<i>Other Costs Total without Interest</i>	<i>110,609.75</i>										
Sum	116,386.28	11,121.60	11,230.48	11,341.54	11,454.82	11,570.36	11,688.22	11,808.43	11,931.04	12,056.11	12,183.68
Costs											
	1,338,730.49	132,197.65	132,550.47	132,910.34	133,277.42	133,651.83	134,033.74	134,423.28	134,820.61	135,225.89	135,639.27
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	982,762.06	107,262.24	105,159.06	103,097.12	101,075.61	99,093.73	97,150.72	95,245.80	93,378.24	91,547.29	89,752.25
Application Value 0,002 €/kWh	88,297.39	9,637.10	9,448.14	9,262.88	9,081.25	8,903.19	8,728.62	8,557.47	8,389.68	8,225.17	8,063.89
Additional Market Profits	342,340.12	31,264.73	31,890.03	32,527.83	33,178.39	33,841.95	34,518.79	35,209.17	35,913.35	36,631.62	37,364.25
Sum	1,413,399.57	148,164.08	146,497.23	144,887.83	143,335.25	141,838.88	140,398.13	139,012.44	137,681.27	136,404.08	135,180.39
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	15,966.43	13,946.76	11,977.48	10,057.83	8,187.05	6,364.39	4,589.16	2,860.66	1,178.20	-458.88	0
Return on Investment		1%	1%	1%	1%	1%	1%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.027	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028

Variant 3-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,650		
Padditional [kWel]	1,045		
CHP 1 [kWel]	550	4,246	2,335,300
CHP 2 (additional CHP) [kWel]	1,100	2,257	2,482,700
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	63.81		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	782,515.18	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	93,500.00	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	88,000.00	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73
Investment Total without Interest	978,015.18										
Sum	1,088,790.35	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03	108,879.03
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		935.00	953.70	972.77	992.23	1,012.07	1,032.32	1,052.96	1,074.02	1,095.50	1,117.41
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		880.00	897.60	915.55	933.86	952.54	971.59	991.02	1,010.84	1,031.06	1,051.68
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	90,066.84	8,225.49	8,390.00	8,557.80	8,728.96	8,903.54	9,081.61	9,263.24	9,448.50	9,637.47	9,830.22
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	59,609.75	5,443.95	5,552.83	5,663.89	5,777.17	5,892.71	6,010.56	6,130.77	6,253.39	6,378.46	6,506.03
Other Costs Total without Interest	110,609.75										
Sum	116,386.28	11,121.60	11,230.48	11,341.54	11,454.82	11,570.36	11,688.22	11,808.43	11,931.04	12,056.11	12,183.68
Costs	1,338,727.11	132,197.34	132,550.15	132,910.02	133,277.09	133,651.50	134,033.39	134,422.93	134,820.25	135,225.52	135,638.90
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	982,649.89	107,250.00	105,147.06	103,085.35	101,064.07	99,082.42	97,139.63	95,234.93	93,367.58	91,536.84	89,742.00
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	384,310.57	35,097.75	35,799.71	36,515.70	37,246.01	37,990.93	38,750.75	39,525.77	40,316.28	41,122.61	41,945.06
Sum	1,455,247.77	151,983.75	150,393.82	148,862.87	147,390.30	145,975.53	144,618.00	143,317.19	142,072.58	140,883.68	139,750.04
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		19,786.41	17,843.67	15,952.85	14,113.21	12,324.03	10,584.61	8,894.26	7,252.33	5,658.16	4,111.14
Return on Investment		2%	1%	1%	1%	1%	1%	1%	1%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.027	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028

Appendix

Variant 3-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,650		
Padditional [kWel]	1,045		
CHP 1 [kWel]	550	2,920	1,606,000
CHP 2 (additional CHP) [kWel]	1,100	2,920	3,212,000
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	57.46		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	782,515.18	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Control System	93,500.00	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03
Transformer / Grid	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
#BEZUG!	88,000.00	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73
Sum	1,058,773.87										
Supply Costs	1,178,696.19	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System		935.00	953.70	972.77	992.23	1,012.07	1,032.32	1,052.96	1,074.02	1,095.50	1,117.41
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		880.00	897.60	915.55	933.86	952.54	971.59	991.02	1,010.84	1,031.06	1,051.68
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	116,595.39	10,648.25	10,861.22	11,078.44	11,300.01	11,526.01	11,756.53	11,991.66	12,231.49	12,476.12	12,725.65
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	64,531.97	5,893.48	6,011.35	6,131.58	6,254.21	6,379.29	6,506.88	6,637.02	6,769.76	6,905.15	7,043.26
Other Costs Total without Interest	115,531.97										
Sum	121,308.50	11,571.13	11,689.00	11,809.23	11,931.86	12,056.95	12,184.53	12,314.67	12,447.41	12,582.81	12,720.91
Costs	1,460,083.72	144,060.22	144,470.47	144,888.94	145,315.77	145,751.14	146,195.22	146,648.18	147,110.20	147,581.45	148,062.14
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	982,649.89	107,250.00	105,147.06	103,085.35	101,064.07	99,082.42	97,139.63	95,234.93	93,367.58	91,536.84	89,742.00
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	346,025.43	31,601.30	32,233.33	32,877.99	33,535.55	34,206.26	34,890.39	35,588.20	36,299.96	37,025.96	37,766.48
Sum	1,416,962.63	148,487.30	146,827.44	145,225.17	143,679.84	142,190.86	140,757.64	139,379.62	138,056.26	136,787.04	135,571.46
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		4,427.09	2,356.97	336.23	-1,635.93	-3,560.28	-5,437.58	-7,268.56	-9,053.94	-10,794.42	-12,490.68
Return on Investment		0%	0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.031	0.031	0.031

Variant 3-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,650		
Padditional [kWel]	1,045		
CHP 1 [kWel]	550	3,130	1,721,500
CHP 2 (additional CHP) [kWel]	1,100	2,816	3,097,600
Total Electricity Production [kWhel/a]	4,819,100		
Additional Earnings Electricity Market [€/kWel; rated a]	69.66		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	782,515.18	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	93,500.00	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	88,000.00	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73
<i>Investment Total without Interest</i>	1,058,773.87										
Sum	1,178,696.19	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,706.11	2,760.23	2,815.44	2,871.75	2,929.18	2,987.76	3,047.52	3,108.47	3,170.64	3,234.05
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System	935.00	953.70	972.77	992.23	1,012.07	1,032.32	1,052.96	1,074.02	1,095.50	1,117.41	
Control System	120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41	
Transformer / Grid	880.00	897.60	915.55	933.86	952.54	971.59	991.02	1,010.84	1,031.06	1,051.68	
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	116,602.16	10,648.87	10,861.85	11,079.08	11,300.67	11,526.68	11,757.21	11,992.36	12,232.20	12,476.85	12,726.39
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	64,531.97	5,893.48	6,011.35	6,131.58	6,254.21	6,379.29	6,506.88	6,637.02	6,769.76	6,905.15	7,043.26
<i>Other Costs Total without Interest</i>	115,531.97										
Sum	121,308.50	11,571.13	11,689.00	11,809.23	11,931.86	12,056.95	12,184.53	12,314.67	12,447.41	12,582.81	12,720.91
Costs	1,460,090.49	144,060.83	144,471.10	144,889.58	145,316.43	145,751.81	146,195.90	146,648.87	147,110.91	147,582.18	148,062.88
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	982,874.24	107,274.49	105,171.07	103,108.89	101,087.14	99,105.04	97,161.81	95,256.67	93,388.90	91,557.74	89,762.49
Application Value 0,002 €/kWh	88,307.47	9,638.20	9,449.22	9,263.94	9,082.29	8,904.21	8,729.61	8,558.45	8,390.63	8,226.11	8,064.81
Additional Market Profits	419,531.10	38,314.32	39,080.61	39,862.22	40,659.46	41,472.65	42,302.10	43,148.15	44,011.11	44,891.33	45,789.16
Sum	1,490,712.81	155,227.01	153,700.89	152,235.04	150,828.90	149,481.90	148,193.53	146,963.27	145,790.64	144,675.18	143,616.46
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		11,166.17	9,229.78	7,345.46	5,512.47	3,730.09	1,997.63	314.39	-1,320.27	-2,906.99	-4,446.41
Return on Investment		1%	1%	1%	0%	0%	0%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.031	0.031	0.031

Appendix

Variant 3-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,650		
Padditional [kWel]	1,045		
CHP 1 [kWel]	550	3,174	1,745,700
CHP 2 (additional CHP) [kWel]	1,100	2,793	3,072,300
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	81.20		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	1976

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	782,515.18	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70
Additional Gas Storage	80,758.69	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58	8,990.58
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	93,500.00	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	88,000.00	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73
<i>Investment Total without Interest</i>	<i>1,058,773.87</i>										
Sum	1,178,696.19	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62	117,869.62
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		2,722.76	2,777.22	2,832.76	2,889.42	2,947.20	3,006.15	3,066.27	3,127.60	3,190.15	3,253.95
Gas Conditioning / Gas Pipe System		935.00	953.70	972.77	992.23	1,012.07	1,032.32	1,052.96	1,074.02	1,095.50	1,117.41
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		880.00	897.60	915.55	933.86	952.54	971.59	991.02	1,010.84	1,031.06	1,051.68
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	116,595.39	10,648.25	10,861.22	11,078.44	11,300.01	11,526.01	11,756.53	11,991.66	12,231.49	12,476.12	12,725.65
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	64,531.97	5,893.48	6,011.35	6,131.58	6,254.21	6,379.29	6,506.88	6,637.02	6,769.76	6,905.15	7,043.26
<i>Other Costs Total without Interest</i>	<i>115,531.97</i>										
Sum	121,308.50	11,571.13	11,689.00	11,809.23	11,931.86	12,056.95	12,184.53	12,314.67	12,447.41	12,582.81	12,720.91
Costs	1,460,083.72	144,060.22	144,470.47	144,888.94	145,315.77	145,751.14	146,195.22	146,648.18	147,110.20	147,581.45	148,062.14
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	982,649.89	107,250.00	105,147.06	103,085.35	101,064.07	99,082.42	97,139.63	95,234.93	93,367.58	91,536.84	89,742.00
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	489,012.55	44,659.82	45,553.01	46,464.08	47,393.36	48,341.22	49,308.05	50,294.21	51,300.09	52,326.10	53,372.62
Sum	1,559,949.75	161,545.82	160,147.13	158,811.25	157,537.65	156,325.82	155,175.30	154,085.63	153,056.39	152,087.17	151,177.59
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	17,485.60	15,676.66	15,676.66	13,922.31	12,221.87	10,574.68	8,980.08	7,437.45	5,946.19	4,505.72	3,115.46
Return on Investment		1%	1%	1%	1%	1%	1%	1%	1%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.030	0.030	0.030	0.030	0.030	0.030	0.030	0.031	0.031	0.031

Variant 3-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,650		
Padditional [kWel]	1,045		
CHP 1 [kWel]	550	2,920	1,606,000
CHP 2 (additional CHP) [kWel]	1,100	2,920	3,212,000
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	57.46		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	782,515.18	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	93,500.00	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	88,000.00	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73
Investment Total without Interest	1,093,554.76										
Sum	1,217,416.55	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System		935.00	953.70	972.77	992.23	1,012.07	1,032.32	1,052.96	1,074.02	1,095.50	1,117.41
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		880.00	897.60	915.55	933.86	952.54	971.59	991.02	1,010.84	1,031.06	1,051.68
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	128,020.63	11,691.68	11,925.51	12,164.02	12,407.30	12,655.45	12,908.56	13,166.73	13,430.06	13,698.67	13,972.64
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	66,651.86	6,087.08	6,208.82	6,333.00	6,459.66	6,588.85	6,720.63	6,855.04	6,992.14	7,131.99	7,274.63
Other Costs Total without Interest	117,651.86										
Sum	123,428.39	11,764.74	11,886.48	12,010.65	12,137.31	12,266.51	12,398.28	12,532.70	12,669.80	12,809.64	12,952.28
Costs	1,512,349.20	149,169.28	149,604.28	150,047.98	150,500.55	150,962.18	151,433.03	151,913.31	152,403.19	152,902.87	153,412.54
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	982,649.89	107,250.00	105,147.06	103,085.35	101,064.07	99,082.42	97,139.63	95,234.93	93,367.58	91,536.84	89,742.00
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	346,025.43	31,601.30	32,233.33	32,877.99	33,535.55	34,206.26	34,890.39	35,588.20	36,299.96	37,025.96	37,766.48
Sum	1,416,962.63	148,487.30	146,827.44	145,225.17	143,679.84	142,190.86	140,757.64	139,379.62	138,056.26	136,787.04	135,571.46
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-681.98	-2,776.83	-4,822.81	-6,820.71	-8,771.32	-10,675.39	-12,533.69	-14,346.93	-16,115.83	-17,841.08
Return on Investment		0%	0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.031	0.031	0.031	0.031	0.031	0.031	0.032	0.032	0.032	0.032

Appendix

Variant 3-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,650		
Padditional [kWel]	1,045		
CHP 1 [kWel]	550	3,026	1,664,300
CHP 2 (additional CHP) [kWel]	1,100	2,868	3,154,800
Total Electricity Production [kWhel/a]	4,819,100		
Additional Earnings Electricity Market [€/kWel; rated a]	78.29		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	782,515.18	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	93,500.00	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	88,000.00	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73
<i>Investment Total without Interest</i>	1,093,554.76										
Sum	1,217,416.55	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,706.11	2,760.23	2,815.44	2,871.75	2,929.18	2,987.76	3,047.52	3,108.47	3,170.64	3,234.05
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System		935.00	953.70	972.77	992.23	1,012.07	1,032.32	1,052.96	1,074.02	1,095.50	1,117.41
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		880.00	897.60	915.55	933.86	952.54	971.59	991.02	1,010.84	1,031.06	1,051.68
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	128,027.39	11,692.30	11,926.14	12,164.67	12,407.96	12,656.12	12,909.24	13,167.43	13,430.77	13,699.39	13,973.38
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	66,651.86	6,087.08	6,208.82	6,333.00	6,459.66	6,588.85	6,720.63	6,855.04	6,992.14	7,131.99	7,274.63
<i>Other Costs Total without Interest</i>	117,651.86										
Sum	123,428.39	11,764.74	11,886.48	12,010.65	12,137.31	12,266.51	12,398.28	12,532.70	12,669.80	12,809.64	12,952.28
Costs	1,512,355.96	149,169.90	149,604.91	150,048.62	150,501.21	150,962.85	151,433.72	151,914.00	152,403.90	152,903.59	153,413.28
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	982,874.24	107,274.49	105,171.07	103,108.89	101,087.14	99,105.04	97,161.81	95,256.67	93,388.90	91,557.74	89,762.49
Application Value 0,002 €/kWh	88,307.47	9,638.20	9,449.22	9,263.94	9,082.29	8,904.21	8,729.61	8,558.45	8,390.63	8,226.11	8,064.81
Additional Market Profits	471,481.29	43,058.75	43,919.92	44,798.32	45,694.29	46,608.17	47,540.34	48,491.14	49,460.97	50,450.19	51,459.19
Sum	1,542,662.99	159,971.44	158,540.20	157,171.15	155,863.72	154,617.43	153,431.76	152,306.26	151,240.50	150,234.04	149,286.50
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	10,801.54	8,935.30	7,122.53	5,362.52	3,654.58	1,998.04	392.26	-1,163.40	-2,669.55	-4,126.78	-5,683.28
Return on Investment		1%	1%	1%	0%	0%	0%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.031	0.031	0.031	0.031	0.031	0.031	0.032	0.032	0.032	0.032

Variant 3-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	550		
Installed Capacity [kWel]	1,650		
Padditional [kWel]	1,045		
CHP 1 [kWel]	550	3,052	1,678,600
CHP 2 (additional CHP) [kWel]	1,100	2,854	3,139,400
Total Electricity Production [kWhel/a]	4,818,000		
Additional Earnings Electricity Market [€/kWel; rated a]	92.80		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	5927

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	782,515.18	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70	87,114.70
Additional Gas Storage	115,539.58	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62	12,862.62
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	93,500.00	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03	10,409.03
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	88,000.00	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73	9,796.73
Investment Total without Interest	1,093,554.76										
Sum	1,217,416.55	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65	121,741.65
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		138.71	141.48	144.31	147.20	150.14	153.15	156.21	159.33	162.52	165.77
Sum	43,483.64	3,971.21	4,050.63	4,131.65	4,214.28	4,298.57	4,384.54	4,472.23	4,561.67	4,652.91	4,745.96
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		2,705.49	2,759.60	2,814.79	2,871.09	2,928.51	2,987.08	3,046.82	3,107.76	3,169.91	3,233.31
Rated Power [kWel]		3,766.19	3,841.51	3,918.34	3,996.71	4,076.64	4,158.18	4,241.34	4,326.17	4,412.69	4,500.94
Gas Conditioning / Gas Pipe System	935.00	953.70	972.77	992.23	1,012.07	1,032.32	1,052.96	1,074.02	1,095.50	1,117.41	
Control System	120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41	
Transformer / Grid	880.00	897.60	915.55	933.86	952.54	971.59	991.02	1,010.84	1,031.06	1,051.68	
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	128,020.63	11,691.68	11,925.51	12,164.02	12,407.30	12,655.45	12,908.56	13,166.73	13,430.06	13,698.67	13,972.64
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	66,651.86	6,087.08	6,208.82	6,333.00	6,459.66	6,588.85	6,720.63	6,855.04	6,992.14	7,131.99	7,274.63
Other Costs Total without Interest	117,651.86										
Sum	123,428.39	11,764.74	11,886.48	12,010.65	12,137.31	12,266.51	12,398.28	12,532.70	12,669.80	12,809.64	12,952.28
Costs	1,512,349.20	149,169.28	149,604.28	150,047.98	150,500.55	150,962.18	151,433.03	151,913.31	152,403.19	152,902.87	153,412.54
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	982,649.89	107,250.00	105,147.06	103,085.35	101,064.07	99,082.42	97,139.63	95,234.93	93,367.58	91,536.84	89,742.00
Application Value 0,002 €/kWh	88,287.31	9,636.00	9,447.06	9,261.82	9,080.22	8,902.17	8,727.62	8,556.49	8,388.72	8,224.23	8,062.97
Additional Market Profits	558,899.42	51,042.34	52,063.19	53,104.45	54,166.54	55,249.87	56,354.87	57,481.97	58,631.61	59,804.24	61,000.32
Sum	1,629,836.61	167,928.34	166,657.31	165,451.63	164,310.83	163,234.47	162,222.12	161,273.39	160,387.90	159,565.32	158,805.30
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		18,759.06	17,053.03	15,403.65	13,810.28	12,272.29	10,789.09	9,360.08	7,984.72	6,662.45	5,392.76
Return on Investment		1%	1%	1%	1%	1%	1%	1%	1%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.031	0.031	0.031	0.031	0.031	0.031	0.032	0.032	0.032	0.032

A.3 $P_{\text{rated}} = 750 \text{ kW}_{\text{el}}$

Variant 1.25-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	938		
Padditional [kWel]	113		
CHP 1 [kWel]	750	6,935	5,201,250
CHP 2 (additional CHP) [kWel]	188	7,300	1,368,750
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	237,043.78	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	15,937.50	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	15,000.00	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90
Investment Total without Interest	281,981.28										
Sum	313,919.97	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		150.00	153.00	156.06	159.18	162.36	165.61	168.92	172.30	175.75	179.26
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	79,167.55	7,230.10	7,374.70	7,522.19	7,672.64	7,826.09	7,982.61	8,142.26	8,305.11	8,471.21	8,640.64
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	17,186.68	1,569.60	1,600.99	1,633.01	1,665.67	1,698.99	1,732.97	1,767.62	1,802.98	1,839.04	1,875.82
Other Costs Total without Interest	68,186.68										
Sum	73,963.21	7,247.25	7,278.64	7,310.66	7,343.32	7,376.64	7,410.62	7,445.28	7,480.63	7,516.69	7,553.47
Costs	511,366.05	49,916.51	50,173.45	50,435.53	50,702.84	50,975.51	51,253.62	51,537.30	51,826.66	52,121.80	52,422.84
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	133,997.71	14,625.00	14,338.24	14,057.09	13,781.46	13,511.24	13,246.31	12,986.58	12,731.94	12,482.30	12,237.55
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	180,577.83	16,491.55	16,821.38	17,157.81	17,500.96	17,850.98	18,208.00	18,572.16	18,943.60	19,322.48	19,708.92
Sum	434,967.34	44,256.55	44,041.97	43,844.66	43,664.54	43,501.55	43,355.62	43,226.69	43,114.71	43,019.64	42,941.43
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-5,659.97	-6,131.48	-6,590.87	-7,038.30	-7,473.96	-7,898.01	-8,310.62	-8,711.95	-9,102.16	-9,481.40
Return on Investment		-1%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008

Variant 1.25-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	938		
Padditional [kWel]	113		
CHP 1 [kWel]	750	7,094	5,320,500
CHP 2 (additional CHP) [kWel]	188	6,675	1,251,563
Total Electricity Production [kWhel/a]	6,572,063		
Additional Earnings Electricity Market [€/kWel; rated a]	23.85		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	237,043.78	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	15,937.50	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	15,000.00	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90
Investment Total without Interest	281,981.28										
Sum	313,919.97	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,376.16	3,443.68	3,512.55	3,582.80	3,654.46	3,727.55	3,802.10	3,878.14	3,955.71	4,034.82
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		159.38	162.56	165.81	169.13	172.51	175.96	179.48	183.07	186.73	190.47
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		150.00	153.00	156.06	159.18	162.36	165.61	168.92	172.30	175.75	179.26
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	80,924.26	7,390.53	7,538.34	7,689.11	7,842.89	7,999.75	8,159.74	8,322.94	8,489.40	8,659.19	8,832.37
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	17,186.68	1,569.60	1,600.99	1,633.01	1,665.67	1,698.99	1,732.97	1,767.62	1,802.98	1,839.04	1,875.82
Other Costs Total without Interest	68,186.68										
Sum	73,963.21	7,247.25	7,278.64	7,310.66	7,343.32	7,376.64	7,410.62	7,445.28	7,480.63	7,516.69	7,553.47
Costs	513,122.77	50,076.95	50,337.09	50,602.44	50,873.10	51,149.17	51,430.76	51,717.98	52,010.95	52,309.77	52,614.57
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	134,039.78	14,629.59	14,342.74	14,061.51	13,785.79	13,515.48	13,250.47	12,990.66	12,735.94	12,486.22	12,241.39
Application Value 0,002 €/kWh	120,429.58	13,144.13	12,886.40	12,633.72	12,386.00	12,143.14	11,905.04	11,671.61	11,442.75	11,218.38	10,998.42
Additional Market Profits	195,840.87	17,885.47	18,243.18	18,608.04	18,980.20	19,359.80	19,747.00	20,141.94	20,544.78	20,955.68	21,374.79
Sum	450,310.24	45,659.18	45,472.31	45,303.27	45,151.99	45,018.43	44,902.51	44,804.21	44,723.47	44,660.27	44,614.59
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-4,417.76	-4,864.78	-5,299.17	-5,721.10	-6,130.74	-6,528.25	-6,913.77	-7,287.47	-7,649.50	-7,999.98
Return on Investment		-1%	-1%	-1%	-1%	-2%	-2%	-2%	-2%	-2%	-2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008

Appendix

Variant 1.25-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	938		
Padditional [kWel]	113		
CHP 1 [kWel]	750	7,070	5,302,500
CHP 2 (additional CHP) [kWel]	188	6,760	1,267,500
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	26.24		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	237,043.78	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	15,937.50	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	15,000.00	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90
<i>Investment Total without Interest</i>	281,981.28										
Sum	313,919.97	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00	31,392.00
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		159.38	162.56	165.81	169.13	172.51	175.96	179.48	183.07	186.73	190.47
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		150.00	153.00	156.06	159.18	162.36	165.61	168.92	172.30	175.75	179.26
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	80,912.66	7,389.47	7,537.26	7,688.01	7,841.77	7,998.60	8,158.57	8,321.75	8,488.18	8,657.94	8,831.10
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	17,186.68	1,569.60	1,600.99	1,633.01	1,665.67	1,698.99	1,732.97	1,767.62	1,802.98	1,839.04	1,875.82
<i>Other Costs Total without Interest</i>	68,186.68										
Sum	73,963.21	7,247.25	7,278.64	7,310.66	7,343.32	7,376.64	7,410.62	7,445.28	7,480.63	7,516.69	7,553.47
Costs	513,111.17	50,075.89	50,336.01	50,601.34	50,871.97	51,148.02	51,429.59	51,716.79	52,009.73	52,308.53	52,613.31
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	133,997.71	14,625.00	14,338.24	14,057.09	13,781.46	13,511.24	13,246.31	12,986.58	12,731.94	12,482.30	12,237.55
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	215,488.54	19,679.82	20,073.42	20,474.89	20,884.38	21,302.07	21,728.11	22,162.67	22,605.93	23,058.05	23,519.21
Sum	469,878.04	47,444.82	47,294.01	47,161.74	47,047.96	46,952.64	46,875.73	46,817.20	46,777.03	46,755.21	46,751.72
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-2,631.07	-3,042.01	-3,439.60	-3,824.01	-4,195.38	-4,553.86	-4,899.59	-5,232.70	-5,553.32	-5,861.59	-6,161.59
Return on Investment		-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008

Variant 1.25-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	938		
Padditional [kWel]	113		
CHP 1 [kWel]	750	6,935	5,201,250
CHP 2 (additional CHP) [kWel]	188	7,300	1,368,750
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	237,043.78	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	15,937.50	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	15,000.00	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90
Investment Total without Interest	371,332.61										
Sum	413,391.70	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		159.38	162.56	165.81	169.13	172.51	175.96	179.48	183.07	186.73	190.47
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		150.00	153.00	156.06	159.18	162.36	165.61	168.92	172.30	175.75	179.26
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	110,263.82	10,070.01	10,271.41	10,476.84	10,686.38	10,900.10	11,118.11	11,340.47	11,567.28	11,798.62	12,034.60
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	22,632.62	2,066.96	2,108.30	2,150.46	2,193.47	2,237.34	2,282.09	2,327.73	2,374.29	2,421.77	2,470.21
Other Costs Total without Interest	73,632.62										
Sum	79,409.15	7,744.61	7,785.95	7,828.12	7,871.13	7,915.00	7,959.74	8,005.38	8,051.94	8,099.42	8,147.86
Costs	647,379.99	63,200.96	63,524.64	63,854.80	64,191.56	64,535.05	64,885.42	65,242.79	65,607.31	65,979.12	66,358.36
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	133,997.71	14,625.00	14,338.24	14,057.09	13,781.46	13,511.24	13,246.31	12,986.58	12,731.94	12,482.30	12,237.55
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	180,577.83	16,491.55	16,821.38	17,157.81	17,500.96	17,850.98	18,208.00	18,572.16	18,943.60	19,322.48	19,708.92
Sum	434,967.34	44,256.55	44,041.97	43,844.66	43,664.54	43,501.55	43,355.62	43,226.69	43,114.71	43,019.64	42,941.43
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-18,944.41	-19,482.67	-20,010.14	-20,527.02	-21,033.50	-21,529.80	-22,016.10	-22,492.60	-22,959.48	-23,416.93
Return on Investment		-4%	-4%	-4%	-4%	-4%	-4%	-4%	-5%	-5%	-5%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010

Appendix

Variant 1.25-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	938		
Padditional [kWel]	113		
CHP 1 [kWel]	750	7,093	5,319,750
CHP 2 (additional CHP) [kWel]	188	6,675	1,251,563
Total Electricity Production [kWhel/a]	6,571,313		
Additional Earnings Electricity Market [€/kWel; rated a]	26.55		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	237,043.78	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	15,937.50	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	15,000.00	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90
<i>Investment Total without Interest</i>	371,332.61										
Sum	413,391.70	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.77	3,443.29	3,512.15	3,582.40	3,654.04	3,727.12	3,801.67	3,877.70	3,955.25	4,034.36
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		159.38	162.56	165.81	169.13	172.51	175.96	179.48	183.07	186.73	190.47
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		150.00	153.00	156.06	159.18	162.36	165.61	168.92	172.30	175.75	179.26
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	110,271.21	10,070.69	10,272.10	10,477.54	10,687.09	10,900.83	11,118.85	11,341.23	11,568.05	11,799.41	12,035.40
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	22,632.62	2,066.96	2,108.30	2,150.46	2,193.47	2,237.34	2,282.09	2,327.73	2,374.29	2,421.77	2,470.21
<i>Other Costs Total without Interest</i>	73,632.62										
Sum	79,409.15	7,744.61	7,785.95	7,828.12	7,871.13	7,915.00	7,959.74	8,005.38	8,051.94	8,099.42	8,147.86
Costs	647,387.37	63,201.63	63,525.33	63,855.50	64,192.27	64,535.78	64,886.16	65,243.55	65,608.08	65,979.91	66,359.17
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	134,024.48	14,627.92	14,341.10	14,059.90	13,784.22	13,513.94	13,248.96	12,989.18	12,734.49	12,484.79	12,239.99
Application Value 0,002 €/kWh	120,415.84	13,142.63	12,884.93	12,632.28	12,384.59	12,141.75	11,903.68	11,670.27	11,441.45	11,217.10	10,997.16
Additional Market Profits	218,075.86	19,916.11	20,314.43	20,720.72	21,135.14	21,557.84	21,989.00	22,428.78	22,877.35	23,334.90	23,801.60
Sum	472,516.18	47,686.66	47,540.46	47,412.90	47,303.94	47,213.53	47,141.64	47,088.23	47,053.28	47,036.79	47,038.75
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-15,514.97	-15,984.87	-16,442.59	-16,888.33	-17,322.25	-17,744.52	-18,155.32	-18,554.80	-18,943.11	-19,320.42	-19,687.42
Return on Investment		-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010

Variant 1.25-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	938		
Padditional [kWel]	113		
CHP 1 [kWel]	750	7,045	5,283,750
CHP 2 (additional CHP) [kWel]	188	6,860	1,286,250
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	30.23		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	237,043.78	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	15,937.50	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	15,000.00	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90
Investment Total without Interest	371,332.61										
Sum	413,391.70	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17	41,339.17
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		159.38	162.56	165.81	169.13	172.51	175.96	179.48	183.07	186.73	190.47
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		150.00	153.00	156.06	159.18	162.36	165.61	168.92	172.30	175.75	179.26
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	110,263.82	10,070.01	10,271.41	10,476.84	10,686.38	10,900.10	11,118.11	11,340.47	11,567.28	11,798.62	12,034.60
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	22,632.62	2,066.96	2,108.30	2,150.46	2,193.47	2,237.34	2,282.09	2,327.73	2,374.29	2,421.77	2,470.21
Other Costs Total without Interest	73,632.62										
Sum	79,409.15	7,744.61	7,785.95	7,828.12	7,871.13	7,915.00	7,959.74	8,005.38	8,051.94	8,099.42	8,147.86
Costs	647,379.99	63,200.96	63,524.64	63,854.80	64,191.56	64,535.05	64,885.42	65,242.79	65,607.31	65,979.12	66,358.36
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	133,997.71	14,625.00	14,338.24	14,057.09	13,781.46	13,511.24	13,246.31	12,986.58	12,731.94	12,482.30	12,237.55
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	248,255.15	22,672.28	23,125.73	23,588.24	24,060.01	24,541.21	25,032.03	25,532.67	26,043.32	26,564.19	27,095.47
Sum	502,644.65	50,437.28	50,346.31	50,275.09	50,223.59	50,191.77	50,179.65	50,187.20	50,214.43	50,261.35	50,327.98
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-12,763.68	-13,178.33	-13,579.70	-13,967.97	-14,343.28	-14,705.77	-15,055.59	-15,392.88	-15,717.77	-16,030.38
Return on Investment		-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010

Appendix

Variant 1.25-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	938		
Padditional [kWel]	113		
CHP 1 [kWel]	750	6,935	5,201,250
CHP 2 (additional CHP) [kWel]	188	7,300	1,368,750
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	237,043.78	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	15,937.50	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	15,000.00	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90
<i>Investment Total without Interest</i>	409,814.15										
Sum	456,231.86	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		159.38	162.56	165.81	169.13	172.51	175.96	179.48	183.07	186.73	190.47
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		150.00	153.00	156.06	159.18	162.36	165.61	168.92	172.30	175.75	179.26
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	122,904.69	11,224.46	11,448.95	11,677.93	11,911.48	12,149.71	12,392.71	12,640.56	12,893.37	13,151.24	13,414.27
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	24,978.06	2,281.16	2,326.78	2,373.32	2,420.78	2,469.20	2,518.58	2,568.96	2,620.33	2,672.74	2,726.20
<i>Other Costs Total without Interest</i>	75,978.06										
Sum	81,754.59	7,958.81	8,004.44	8,050.97	8,098.44	8,146.85	8,196.24	8,246.61	8,297.99	8,350.39	8,403.85
Costs	705,206.46	68,853.62	69,204.68	69,562.75	69,927.99	70,300.53	70,680.53	71,068.12	71,463.47	71,866.72	72,278.04
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	133,997.71	14,625.00	14,338.24	14,057.09	13,781.46	13,511.24	13,246.31	12,986.58	12,731.94	12,482.30	12,237.55
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	180,577.83	16,491.55	16,821.38	17,157.81	17,500.96	17,850.98	18,208.00	18,572.16	18,943.60	19,322.48	19,708.92
Sum	434,967.34	44,256.55	44,041.97	43,844.66	43,664.54	43,501.55	43,355.62	43,226.69	43,114.71	43,019.64	42,941.43
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-24,597.07	-25,162.71	-25,718.10	-26,263.45	-26,798.99	-27,324.91	-27,841.44	-28,348.76	-28,847.09	-29,336.60
Return on Investment		-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%	-5%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.010	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011

Variant 1.25-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	938		
Padditional [kWel]	113		
CHP 1 [kWel]	750	7,093	5,319,750
CHP 2 (additional CHP) [kWel]	188	6,675	1,251,563
Total Electricity Production [kWhel/a]	6,571,313		
Additional Earnings Electricity Market [€/kWel; rated a]	28.02		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	237,043.78	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	15,937.50	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	15,000.00	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90
Investment Total without Interest	409,814.15										
Sum	456,231.86	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.77	3,443.29	3,512.15	3,582.40	3,654.04	3,727.12	3,801.67	3,877.70	3,955.25	4,034.36
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		159.38	162.56	165.81	169.13	172.51	175.96	179.48	183.07	186.73	190.47
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		150.00	153.00	156.06	159.18	162.36	165.61	168.92	172.30	175.75	179.26
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	122,912.07	11,225.13	11,449.64	11,678.63	11,912.20	12,150.44	12,393.45	12,641.32	12,894.15	13,152.03	13,415.07
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	24,978.06	2,281.16	2,326.78	2,373.32	2,420.78	2,469.20	2,518.58	2,568.96	2,620.33	2,672.74	2,726.20
Other Costs Total without Interest	75,978.06										
Sum	81,754.59	7,958.81	8,004.44	8,050.97	8,098.44	8,146.85	8,196.24	8,246.61	8,297.99	8,350.39	8,403.85
Costs	705,213.84	68,854.30	69,205.36	69,563.46	69,928.71	70,301.26	70,681.27	71,068.88	71,464.24	71,867.51	72,278.84
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	134,024.48	14,627.92	14,341.10	14,059.90	13,784.22	13,513.94	13,248.96	12,989.18	12,734.49	12,484.79	12,239.99
Application Value 0,002 €/kWh	120,415.84	13,142.63	12,884.93	12,632.28	12,384.59	12,141.75	11,903.68	11,670.27	11,441.45	11,217.10	10,997.16
Additional Market Profits	230,119.36	21,016.00	21,436.32	21,865.05	22,302.35	22,748.40	23,203.36	23,667.43	24,140.78	24,623.60	25,116.07
Sum	484,559.69	48,786.55	48,662.35	48,557.23	48,471.16	48,404.09	48,356.00	48,326.88	48,316.71	48,325.49	48,353.22
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-20,067.75	-20,543.02	-21,006.22	-21,457.55	-21,897.18	-22,325.27	-22,742.00	-23,147.53	-23,542.02	-23,925.62
Return on Investment		-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.010	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011

Appendix

Variant 1.25-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	938		
Padditional [kWel]	113		
CHP 1 [kWel]	750	7,012	5,259,000
CHP 2 (additional CHP) [kWel]	188	6,992	1,311,000
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	33.35		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	237,043.78	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26	26,389.26
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	15,937.50	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27	1,774.27
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	15,000.00	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90	1,669.90
<i>Investment Total without Interest</i>	409,814.15										
Sum	456,231.86	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19	45,623.19
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		159.38	162.56	165.81	169.13	172.51	175.96	179.48	183.07	186.73	190.47
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		150.00	153.00	156.06	159.18	162.36	165.61	168.92	172.30	175.75	179.26
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	122,904.69	11,224.46	11,448.95	11,677.93	11,911.48	12,149.71	12,392.71	12,640.56	12,893.37	13,151.24	13,414.27
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	24,978.06	2,281.16	2,326.78	2,373.32	2,420.78	2,469.20	2,518.58	2,568.96	2,620.33	2,672.74	2,726.20
<i>Other Costs Total without Interest</i>	75,978.06										
Sum	81,754.59	7,958.81	8,004.44	8,050.97	8,098.44	8,146.85	8,196.24	8,246.61	8,297.99	8,350.39	8,403.85
Costs	705,206.46	68,853.62	69,204.68	69,562.75	69,927.99	70,300.53	70,680.53	71,068.12	71,463.47	71,866.72	72,278.04
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	133,997.71	14,625.00	14,338.24	14,057.09	13,781.46	13,511.24	13,246.31	12,986.58	12,731.94	12,482.30	12,237.55
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	273,920.90	25,016.24	25,516.57	26,026.90	26,547.44	27,078.39	27,619.96	28,172.35	28,735.80	29,310.52	29,896.73
Sum	528,310.40	52,781.24	52,737.16	52,713.75	52,711.02	52,728.96	52,767.57	52,826.88	52,906.90	53,007.68	53,129.24
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-16,072.38	-16,467.52	-16,849.00	-17,216.97	-17,571.58	-17,912.96	-18,241.24	-18,556.56	-18,859.04	-19,148.80
Return on Investment		-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.010	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011

Variant 1.5-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,125		
Padditional [kWel]	300		
CHP 1 [kWel]	750	6,205	4,653,750
CHP 2 (additional CHP) [kWel]	375	5,110	1,916,250
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	32.18		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	378,463.34	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	31,875.00	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	30,000.00	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80
Investment Total without Interest	454,338.34										
Sum	505,799.10	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		318.75	325.13	331.63	338.26	345.03	351.93	358.96	366.14	373.47	380.94
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	84,300.23	7,698.85	7,852.82	8,009.88	8,170.08	8,333.48	8,500.15	8,670.15	8,843.56	9,020.43	9,200.84
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	27,691.80	2,529.00	2,579.58	2,631.17	2,683.79	2,737.47	2,792.22	2,848.06	2,905.02	2,963.12	3,022.38
Other Costs Total without Interest	78,691.80										
Sum	84,468.32	8,206.65	8,257.23	8,308.82	8,361.44	8,415.12	8,469.87	8,525.71	8,582.67	8,640.77	8,700.04
Costs	718,882.98	70,532.57	70,818.07	71,109.28	71,406.31	71,709.29	72,018.32	72,333.54	72,655.06	72,983.01	73,317.52
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	357,327.23	39,000.00	38,235.29	37,485.58	36,750.57	36,029.97	35,323.50	34,630.88	33,951.85	33,286.12	32,633.46
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	264,262.62	24,134.19	24,616.87	25,109.21	25,611.39	26,123.62	26,646.09	27,179.01	27,722.59	28,277.05	28,842.59
Sum	741,981.64	76,274.19	75,734.52	75,224.55	74,744.08	74,292.92	73,870.90	73,477.84	73,113.60	72,778.03	72,471.01
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		5,741.62	4,916.45	4,115.27	3,337.76	2,583.63	1,852.57	1,144.30	458.54	-204.97	-846.51
Return on Investment		1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011

Appendix

Variant 1.5-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,125		
Padditional [kWel]	300		
CHP 1 [kWel]	750	6,101	4,575,536
CHP 2 (additional CHP) [kWel]	375	5,319	1,994,464
Total Electricity Production [kWhel/a]	6,569,999		
Additional Earnings Electricity Market [€/kWel; rated a]	35.06		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	378,463.34	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	31,875.00	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	30,000.00	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80
Investment Total without Interest	454,338.34										
Sum	505,799.10	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		318.75	325.13	331.63	338.26	345.03	351.93	358.96	366.14	373.47	380.94
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	84,300.23	7,698.85	7,852.82	8,009.88	8,170.08	8,333.48	8,500.15	8,670.15	8,843.56	9,020.43	9,200.83
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	27,691.80	2,529.00	2,579.58	2,631.17	2,683.79	2,737.47	2,792.22	2,848.06	2,905.02	2,963.12	3,022.38
Other Costs Total without Interest	78,691.80										
Sum	84,468.32	8,206.65	8,257.23	8,308.82	8,361.44	8,415.12	8,469.87	8,525.71	8,582.67	8,640.77	8,700.04
Costs											
	718,882.97	70,532.57	70,818.07	71,109.28	71,406.31	71,709.29	72,018.32	72,333.54	72,655.06	72,983.01	73,317.52
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	357,327.20	39,000.00	38,235.29	37,485.58	36,750.57	36,029.97	35,323.50	34,630.88	33,951.84	33,286.12	32,633.45
Application Value 0,002 €/kWh	120,391.78	13,140.00	12,882.35	12,629.76	12,382.11	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	287,947.64	26,297.26	26,823.20	27,359.67	27,906.86	28,465.00	29,034.30	29,614.98	30,207.28	30,811.43	31,427.66
Sum	765,666.62	78,437.25	77,940.85	77,475.00	77,039.54	76,634.29	76,259.10	75,913.81	75,598.29	75,312.41	75,056.07
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		7,904.68	7,122.78	6,365.72	5,633.23	4,925.00	4,240.77	3,580.27	2,943.23	2,329.40	1,738.56
Return on Investment		1%	1%	1%	1%	1%	1%	1%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011

Variant 1.5-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,125		
Padditional [kWel]	300		
CHP 1 [kWel]	750	6,085	4,563,750
CHP 2 (additional CHP) [kWel]	375	5,350	2,006,250
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	38.25		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	378,463.34	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Füllstandsüberwachung weiterer Behälter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Conditioning / Gas Pipe System	31,875.00	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	30,000.00	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80
<i>Investment Total without Interest</i>	454,338.34										
Sum	505,799.10	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91	50,579.91
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		318.75	325.13	331.63	338.26	345.03	351.93	358.96	366.14	373.47	380.94
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	84,300.23	7,698.85	7,852.82	8,009.88	8,170.08	8,333.48	8,500.15	8,670.15	8,843.56	9,020.43	9,200.84
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	27,691.80	2,529.00	2,579.58	2,631.17	2,683.79	2,737.47	2,792.22	2,848.06	2,905.02	2,963.12	3,022.38
<i>Other Costs Total without Interest</i>	78,691.80										
Sum	84,468.32	8,206.65	8,257.23	8,308.82	8,361.44	8,415.12	8,469.87	8,525.71	8,582.67	8,640.77	8,700.04
Costs	718,882.98	70,532.57	70,818.07	71,109.28	71,406.31	71,709.29	72,018.32	72,333.54	72,655.06	72,983.01	73,317.52
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	357,327.23	39,000.00	38,235.29	37,485.58	36,750.57	36,029.97	35,323.50	34,630.88	33,951.85	33,286.12	32,633.46
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	314,120.12	28,687.50	29,261.25	29,846.48	30,443.40	31,052.27	31,673.32	32,306.78	32,952.92	33,611.98	34,284.22
Sum	791,839.14	80,827.50	80,378.90	79,961.82	79,576.09	79,221.57	78,898.12	78,605.61	78,343.93	78,112.97	77,912.64
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		10,294.93	9,560.83	8,852.53	8,169.78	7,512.28	6,879.80	6,272.07	5,688.87	5,129.96	4,595.12
Return on Investment		2%	2%	1%	1%	1%	1%	1%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.011

Appendix

Variant 1.5-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,125		
Padditional [kWel]	300		
CHP 1 [kWel]	750	5,840	4,380,000
CHP 2 (additional CHP) [kWel]	375	5,475	2,053,125
Total Electricity Production [kWhel/a]	6,433,125		
Additional Earnings Electricity Market [€/kWel; rated a]	32.53		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	378,463.34	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	31,875.00	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	30,000.00	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80
Investment Total without Interest	543,689.66										
Sum	605,270.82	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,304.78	3,370.88	3,438.30	3,507.06	3,577.20	3,648.75	3,721.72	3,796.16	3,872.08	3,949.52
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		318.75	325.13	331.63	338.26	345.03	351.93	358.96	366.14	373.47	380.94
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	112,881.47	10,309.07	10,515.25	10,725.56	10,940.07	11,158.87	11,382.05	11,609.69	11,841.88	12,078.72	12,320.30
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	33,137.73	3,026.35	3,086.88	3,148.62	3,211.59	3,275.82	3,341.34	3,408.17	3,476.33	3,545.86	3,616.77
Other Costs Total without Interest	84,137.73										
Sum	89,914.26	8,704.01	8,764.53	8,826.27	8,889.24	8,953.48	9,018.99	9,085.82	9,153.98	9,223.51	9,294.43
Costs											
	852,381.88	83,587.33	83,934.98	84,289.58	84,651.28	85,020.21	85,396.52	85,780.36	86,171.87	86,571.21	86,978.54
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	349,882.91	38,187.50	37,438.73	36,704.63	35,984.93	35,279.35	34,587.60	33,909.41	33,244.52	32,592.66	31,953.59
Application Value 0,002 €/kWh	117,883.63	12,866.25	12,613.97	12,366.64	12,124.15	11,886.43	11,653.36	11,424.86	11,200.84	10,981.22	10,765.90
Additional Market Profits	267,134.08	24,396.43	24,884.36	25,382.04	25,889.69	26,407.48	26,935.63	27,474.34	28,023.83	28,584.30	29,155.99
Sum	734,900.63	75,450.18	74,937.05	74,453.31	73,998.77	73,573.25	73,176.58	72,808.61	72,469.19	72,158.19	71,875.48
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-8,137.15	-8,997.93	-9,836.27	-10,652.51	-11,446.96	-12,219.94	-12,971.75	-13,702.68	-14,413.02	-15,103.06
Return on Investment		-1%	-1%	-1%	-2%	-2%	-2%	-2%	-2%	-2%	-2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.014

Variant 1.5-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,125		
Padditional [kWel]	300		
CHP 1 [kWel]	750	5,892	4,419,105
CHP 2 (additional CHP) [kWel]	375	5,736	2,150,891
Total Electricity Production [kWhel/a]	6,569,996		
Additional Earnings Electricity Market [€/kWel; rated a]	41.68		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	378,463.34	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	31,875.00	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	30,000.00	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80
Investment Total without Interest	543,689.66										
Sum	605,270.82	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.92	3,954.46	4,033.55
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		318.75	325.13	331.63	338.26	345.03	351.93	358.96	366.14	373.47	380.94
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	113,651.37	10,379.39	10,586.97	10,798.71	11,014.69	11,234.98	11,459.68	11,688.87	11,922.65	12,161.10	12,404.33
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	33,137.73	3,026.35	3,086.88	3,148.62	3,211.59	3,275.82	3,341.34	3,408.17	3,476.33	3,545.86	3,616.77
Other Costs Total without Interest	84,137.73										
Sum	89,914.26	8,704.01	8,764.53	8,826.27	8,889.24	8,953.48	9,018.99	9,085.82	9,153.98	9,223.51	9,294.43
Costs	853,151.78	83,657.64	84,006.70	84,362.74	84,725.90	85,096.32	85,474.15	85,859.54	86,252.64	86,653.59	87,062.57
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	357,327.03	38,999.98	38,235.27	37,485.56	36,750.55	36,029.95	35,323.48	34,630.86	33,951.83	33,286.11	32,633.44
Application Value 0,002 €/kWh	120,391.72	13,139.99	12,882.35	12,629.75	12,382.11	12,139.32	11,901.30	11,667.94	11,439.15	11,214.86	10,994.96
Additional Market Profits	342,309.15	31,261.91	31,887.14	32,524.89	33,175.38	33,838.89	34,515.67	35,205.98	35,910.10	36,628.31	37,360.87
Sum	820,027.90	83,401.88	83,004.76	82,640.20	82,308.04	82,008.17	81,740.45	81,504.78	81,301.08	81,129.27	80,989.27
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-255.76	-1,001.94	-1,722.54	-2,417.85	-3,088.15	-3,733.70	-4,354.75	-4,951.55	-5,524.33	-6,073.31
Return on Investment		0%	0%	0%	0%	0%	-1%	-1%	-1%	-1%	-1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013

Appendix

Variant 1.5-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,125		
Padditional [kWel]	300		
CHP 1 [kWel]	750	5,890	4,417,500
CHP 2 (additional CHP) [kWel]	375	5,740	2,152,500
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	45,90		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	378,463.34	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	31,875.00	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	30,000.00	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80
<i>Investment Total without Interest</i>	543,689.66										
Sum	605,270.82	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08	60,527.08
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		318.75	325.13	331.63	338.26	345.03	351.93	358.96	366.14	373.47	380.94
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	113,651.39	10,379.39	10,586.97	10,798.71	11,014.69	11,234.98	11,459.68	11,688.88	11,922.65	12,161.11	12,404.33
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	33,137.73	3,026.35	3,086.88	3,148.62	3,211.59	3,275.82	3,341.34	3,408.17	3,476.33	3,545.86	3,616.77
<i>Other Costs Total without Interest</i>	84,137.73										
Sum	89,914.26	8,704.01	8,764.53	8,826.27	8,889.24	8,953.48	9,018.99	9,085.82	9,153.98	9,223.51	9,294.43
Costs	853,151.80	83,657.64	84,006.70	84,362.74	84,725.90	85,096.32	85,474.15	85,859.54	86,252.64	86,653.60	87,062.57
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	357,327.23	39,000.00	38,235.29	37,485.58	36,750.57	36,029.97	35,323.50	34,630.88	33,951.85	33,286.12	32,633.46
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	376,928.30	34,423.55	35,112.02	35,814.26	36,530.55	37,261.16	38,006.38	38,766.51	39,541.84	40,332.68	41,139.33
Sum	854,647.32	86,563.55	86,229.67	85,929.60	85,663.24	85,430.46	85,231.19	85,065.34	84,932.85	84,833.67	84,767.75
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		2,905.91	2,222.97	1,566.87	937.34	334.14	-242.97	-794.20	-1,319.79	-1,819.93	-2,294.82
Return on Investment		0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013	0.013

Variant 1.5-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,125		
Padditional [kWel]	300		
CHP 1 [kWel]	750	5,840	4,380,000
CHP 2 (additional CHP) [kWel]	375	5,475	2,053,125
Total Electricity Production [kWhel/a]	6,433,125		
Additional Earnings Electricity Market [€/kWel; rated a]	32.53		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	378,463.34	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	31,875.00	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	30,000.00	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80
Investment Total without Interest	582,171.20										
Sum	648,110.99	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,304.78	3,370.88	3,438.30	3,507.06	3,577.20	3,648.75	3,721.72	3,796.16	3,872.08	3,949.52
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		318.75	325.13	331.63	338.26	345.03	351.93	358.96	366.14	373.47	380.94
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	125,522.33	11,463.52	11,692.79	11,926.64	12,165.18	12,408.48	12,656.65	12,909.78	13,167.98	13,431.34	13,699.97
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	35,483.17	3,240.55	3,305.37	3,371.47	3,438.90	3,507.68	3,577.83	3,649.39	3,722.38	3,796.83	3,872.76
Other Costs Total without Interest	86,483.17										
Sum	92,259.70	8,918.21	8,983.02	9,049.13	9,116.56	9,185.33	9,255.49	9,327.04	9,400.03	9,474.48	9,550.42
Costs	910,208.34	89,239.99	89,615.01	89,997.54	90,387.72	90,785.69	91,191.63	91,605.69	92,028.03	92,458.82	92,898.22
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	349,882.91	38,187.50	37,438.73	36,704.63	35,984.93	35,279.35	34,587.60	33,909.41	33,244.52	32,592.66	31,953.59
Application Value 0,002 €/kWh	117,883.63	12,866.25	12,613.97	12,366.64	12,124.15	11,886.43	11,653.36	11,424.86	11,200.84	10,981.22	10,765.90
Additional Market Profits	267,134.08	24,396.43	24,884.36	25,382.04	25,889.69	26,407.48	26,935.63	27,474.34	28,023.83	28,584.30	29,155.99
Sum	734,900.63	75,450.18	74,937.05	74,453.31	73,998.77	73,573.25	73,176.58	72,808.61	72,469.19	72,158.19	71,875.48
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-13,789.81	-14,677.96	-15,544.23	-16,388.94	-17,212.44	-18,015.05	-18,797.08	-19,558.84	-20,300.63	-21,022.73
Return on Investment		-2%	-2%	-2%	-2%	-2%	-2%	-2%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014

Appendix

Variant 1.5-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,125		
Padditional [kWel]	300		
CHP 1 [kWel]	750	5,892	4,419,105
CHP 2 (additional CHP) [kWel]	375	5,736	2,150,891
Total Electricity Production [kWhel/a]	6,569,996		
Additional Earnings Electricity Market [€/kWel; rated a]	45.61		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	378,463.34	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	31,875.00	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	30,000.00	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80
Investment Total without Interest	582,171.20										
Sum	648,110.99	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.92	3,954.46	4,033.55
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		318.75	325.13	331.63	338.26	345.03	351.93	358.96	366.14	373.47	380.94
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	126,292.24	11,533.83	11,764.51	11,999.80	12,239.79	12,484.59	12,734.28	12,988.97	13,248.75	13,513.72	13,784.00
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	35,483.17	3,240.55	3,305.37	3,371.47	3,438.90	3,507.68	3,577.83	3,649.39	3,722.38	3,796.83	3,872.76
Other Costs Total without Interest	86,483.17										
Sum	92,259.70	8,918.21	8,983.02	9,049.13	9,116.56	9,185.33	9,255.49	9,327.04	9,400.03	9,474.48	9,550.42
Costs											
	910,978.25	89,310.30	89,686.73	90,070.69	90,462.33	90,861.80	91,269.26	91,684.87	92,108.80	92,541.20	92,982.25
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	357,327.03	38,999.98	38,235.27	37,485.56	36,750.55	36,029.95	35,323.48	34,630.86	33,951.83	33,286.11	32,633.44
Application Value 0,002 €/kWh	120,391.72	13,139.99	12,882.35	12,629.75	12,382.11	12,139.32	11,901.30	11,667.94	11,439.15	11,214.86	10,994.96
Additional Market Profits	374,538.46	34,205.30	34,889.40	35,587.19	36,298.93	37,024.91	37,765.41	38,520.72	39,291.13	40,076.96	40,878.50
Sum	852,257.20	86,345.27	86,007.02	85,702.50	85,431.59	85,194.19	84,990.19	84,819.52	84,682.12	84,577.92	84,506.89
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-2,965.04	-3,679.71	-4,368.19	-5,030.74	-5,667.62	-6,279.08	-6,865.35	-7,426.68	-7,963.28	-8,475.36
Return on Investment		0%	0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014

Variant 1.5-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,125		
Padditional [kWel]	300		
CHP 1 [kWel]	750	5,861	4,395,750
CHP 2 (additional CHP) [kWel]	375	5,798	2,174,250
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	50.17		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	378,463.34	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01	42,133.01
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	31,875.00	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53	3,548.53
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	30,000.00	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80	3,339.80
Investment Total without Interest	582,171.20										
Sum	648,110.99	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10	64,811.10
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		318.75	325.13	331.63	338.26	345.03	351.93	358.96	366.14	373.47	380.94
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	126,292.26	11,533.83	11,764.51	11,999.80	12,239.80	12,484.59	12,734.28	12,988.97	13,248.75	13,513.72	13,784.00
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	35,483.17	3,240.55	3,305.37	3,371.47	3,438.90	3,507.68	3,577.83	3,649.39	3,722.38	3,796.83	3,872.76
Other Costs Total without Interest	86,483.17										
Sum	92,259.70	8,918.21	8,983.02	9,049.13	9,116.56	9,185.33	9,255.49	9,327.04	9,400.03	9,474.48	9,550.42
Costs	910,978.27	89,310.30	89,686.74	90,070.70	90,462.33	90,861.81	91,269.27	91,684.88	92,108.80	92,541.20	92,982.25
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	357,327.23	39,000.00	38,235.29	37,485.58	36,750.57	36,029.97	35,323.50	34,630.88	33,951.85	33,286.12	32,633.46
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	412,012.06	37,627.63	38,380.18	39,147.79	39,930.74	40,729.36	41,543.95	42,374.82	43,222.32	44,086.77	44,968.50
Sum	889,731.09	89,767.63	89,497.83	89,263.13	89,063.43	88,898.66	88,768.75	88,673.65	88,613.33	88,587.76	88,596.92
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		457.33	-188.90	-807.57	-1,398.90	-1,963.15	-2,500.52	-3,011.22	-3,495.47	-3,953.45	-4,385.33
Return on Investment		0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014	0.014

Appendix

Variant 2-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	675		
CHP 1 [kWel]	750	4,015	3,011,250
CHP 2 (additional CHP) [kWel]	750	4,745	3,558,750
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	43.56		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	604,253.35	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	63,750.00	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	60,000.00	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59
Investment Total without Interest	742,003.35										
Sum	826,046.56	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		637.50	650.25	663.26	676.52	690.05	703.85	717.93	732.29	746.93	761.87
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		600.00	612.00	624.24	636.72	649.46	662.45	675.70	689.21	703.00	717.06
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	91,075.37	8,317.60	8,483.95	8,653.63	8,826.70	9,003.23	9,183.30	9,366.97	9,554.30	9,745.39	9,940.30
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	45,224.90	4,130.23	4,212.84	4,297.09	4,383.04	4,470.70	4,560.11	4,651.31	4,744.34	4,839.23	4,936.01
Other Costs Total without Interest	96,224.90										
Sum	102,001.43	9,807.89	9,890.49	9,974.75	10,060.69	10,148.35	10,237.76	10,328.97	10,421.99	10,516.88	10,613.66
Costs											
	1,063,438.68	104,777.30	105,107.20	105,443.70	105,786.93	106,137.02	106,494.12	106,858.35	107,229.87	107,608.82	107,995.35
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	803,986.27	87,750.00	86,029.41	84,342.56	82,688.78	81,067.44	79,477.88	77,919.49	76,391.66	74,893.78	73,425.27
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	357,700.38	32,667.53	33,320.88	33,987.30	34,667.05	35,360.39	36,067.60	36,788.95	37,524.73	38,275.22	39,040.73
Sum	1,282,078.44	133,557.53	132,232.65	130,959.62	129,737.95	128,567.15	127,446.78	126,376.38	125,355.54	124,383.87	123,460.97
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		28,780.23	27,125.45	25,515.92	23,951.02	22,430.13	20,952.66	19,518.03	18,125.67	16,775.04	15,465.61
Return on Investment		3%	3%	3%	3%	2%	2%	2%	2%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016

Variant 2-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	675		
CHP 1 [kWel]	750	3,651	2,738,250
CHP 2 (additional CHP) [kWel]	750	5,110	3,832,500
Total Electricity Production [kWhel/a]	6,570,750		
Additional Earnings Electricity Market [€/kWel; rated a]	46.65		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	604,253.35	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	63,750.00	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	60,000.00	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59
Investment Total without Interest	742,003.35										
Sum	826,046.56	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.48	3,442.99	3,511.85	3,582.09	3,653.73	3,726.81	3,801.34	3,877.37	3,954.92	4,034.01
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		637.50	650.25	663.26	676.52	690.05	703.85	717.93	732.29	746.93	761.87
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		600.00	612.00	624.24	636.72	649.46	662.45	675.70	689.21	703.00	717.06
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	91,079.59	8,317.98	8,484.34	8,654.03	8,827.11	9,003.65	9,183.72	9,367.40	9,554.75	9,745.84	9,940.76
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	45,224.90	4,130.23	4,212.84	4,297.09	4,383.04	4,470.70	4,560.11	4,651.31	4,744.34	4,839.23	4,936.01
Other Costs Total without Interest	96,224.90										
Sum	102,001.43	9,807.89	9,890.49	9,974.75	10,060.69	10,148.35	10,237.76	10,328.97	10,421.99	10,516.88	10,613.66
Costs	1,063,442.90	104,777.69	105,107.60	105,444.10	105,787.34	106,137.44	106,494.54	106,858.79	107,230.32	107,609.28	107,995.82
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	804,078.05	87,760.02	86,039.23	84,352.19	82,698.22	81,076.69	79,486.95	77,928.38	76,400.38	74,902.33	73,433.66
Application Value 0,002 €/kWh	120,405.53	13,141.50	12,883.82	12,631.20	12,383.53	12,140.71	11,902.66	11,669.28	11,440.47	11,216.14	10,996.22
Additional Market Profits	383,132.40	34,990.15	35,689.95	36,403.75	37,131.83	37,874.47	38,631.95	39,404.59	40,192.69	40,996.54	41,816.47
Sum	1,307,615.98	135,891.67	134,613.01	133,387.14	132,213.58	131,091.87	130,021.57	129,002.25	128,033.53	127,115.01	126,246.35
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		31,113.98	29,505.41	27,943.04	26,426.24	24,954.43	23,527.03	22,143.47	20,803.21	19,505.74	18,250.53
Return on Investment		3%	3%	3%	3%	3%	3%	2%	2%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016

Appendix

Variant 2-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	675		
CHP 1 [kWel]	750	3,650	2,737,500
CHP 2 (additional CHP) [kWel]	750	5,110	3,832,500
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	52.42		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	604,253.35	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	63,750.00	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	60,000.00	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59
Investment Total without Interest	742,003.35										
Sum	826,046.56	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66	82,604.66
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		637.50	650.25	663.26	676.52	690.05	703.85	717.93	732.29	746.93	761.87
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		600.00	612.00	624.24	636.72	649.46	662.45	675.70	689.21	703.00	717.06
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	91,075.37	8,317.60	8,483.95	8,653.63	8,826.70	9,003.23	9,183.30	9,366.97	9,554.30	9,745.39	9,940.30
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	45,224.90	4,130.23	4,212.84	4,297.09	4,383.04	4,470.70	4,560.11	4,651.31	4,744.34	4,839.23	4,936.01
Other Costs Total without Interest	96,224.90										
Sum	102,001.43	9,807.89	9,890.49	9,974.75	10,060.69	10,148.35	10,237.76	10,328.97	10,421.99	10,516.88	10,613.66
Costs	1,063,438.68	104,777.30	105,107.20	105,443.70	105,786.93	106,137.02	106,494.12	106,858.35	107,229.87	107,608.82	107,995.35
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	803,986.27	87,750.00	86,029.41	84,342.56	82,688.78	81,067.44	79,477.88	77,919.49	76,391.66	74,893.78	73,425.27
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	430,506.57	39,316.67	40,103.00	40,905.06	41,723.17	42,557.63	43,408.78	44,276.96	45,162.50	46,065.75	46,987.06
Sum	1,354,884.63	140,206.67	139,014.77	137,877.38	136,794.07	135,764.39	134,787.96	133,864.39	132,993.31	132,174.39	131,407.30
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	35,429.37	33,907.56	32,433.68	31,007.14	29,627.37	28,293.85	27,006.04	25,763.44	24,565.56	23,411.94	22,300.00
Return on Investment		4%	4%	3%	3%	3%	3%	3%	3%	3%	3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016

Variant 2-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	675		
CHP 1 [kWel]	750	4,380	3,285,000
CHP 2 (additional CHP) [kWel]	750	4,380	3,285,000
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	44.92		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	604,253.35	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	63,750.00	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	60,000.00	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59
Investment Total without Interest	831,354.67										
Sum	925,518.29	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		637.50	650.25	663.26	676.52	690.05	703.85	717.93	732.29	746.93	761.87
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		600.00	612.00	624.24	636.72	649.46	662.45	675.70	689.21	703.00	717.06
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	120,426.53	10,998.14	11,218.10	11,442.46	11,671.31	11,904.74	12,142.83	12,385.69	12,633.40	12,886.07	13,143.79
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	50,670.84	4,627.59	4,720.14	4,814.55	4,910.84	5,009.05	5,109.23	5,211.42	5,315.65	5,421.96	5,530.40
Other Costs Total without Interest	101,670.84										
Sum	107,447.36	10,305.24	10,397.80	10,492.20	10,588.49	10,686.71	10,786.89	10,889.07	10,993.30	11,099.61	11,208.05
Costs	1,197,707.51	117,902.37	118,295.83	118,697.16	119,106.51	119,524.05	119,949.95	120,384.35	120,827.45	121,279.41	121,740.41
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	803,986.27	87,750.00	86,029.41	84,342.56	82,688.78	81,067.44	79,477.88	77,919.49	76,391.66	74,893.78	73,425.27
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	368,866.05	33,687.26	34,361.00	35,048.22	35,749.19	36,464.17	37,193.45	37,937.32	38,696.07	39,469.99	40,259.39
Sum	1,293,244.12	134,577.26	133,272.77	132,020.54	130,820.09	129,670.93	128,572.63	127,524.75	126,526.88	125,578.63	124,679.63
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		16,674.88	14,976.93	13,323.38	11,713.57	10,146.88	8,622.69	7,140.40	5,699.43	4,299.22	2,939.22
Return on Investment		2%	1%	1%	1%	1%	1%	1%	1%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.019

Appendix

Variant 2-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	675		
CHP 1 [kWel]	750	4,068	3,051,000
CHP 2 (additional CHP) [kWel]	750	4,693	3,519,750
Total Electricity Production [kWhel/a]	6,570,750		
Additional Earnings Electricity Market [€/kWel; rated a]	54.60		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	604,253.35	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	63,750.00	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	60,000.00	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59
<i>Investment Total without Interest</i>	831,354.67										
Sum	925,518.29	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.48	3,442.99	3,511.85	3,582.09	3,653.73	3,726.81	3,801.34	3,877.37	3,954.92	4,034.01
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		637.50	650.25	663.26	676.52	690.05	703.85	717.93	732.29	746.93	761.87
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		600.00	612.00	624.24	636.72	649.46	662.45	675.70	689.21	703.00	717.06
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	120,430.75	10,998.52	11,218.49	11,442.86	11,671.72	11,905.15	12,143.26	12,386.12	12,633.85	12,886.52	13,144.25
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	50,670.84	4,627.59	4,720.14	4,814.55	4,910.84	5,009.05	5,109.23	5,211.42	5,315.65	5,421.96	5,530.40
<i>Other Costs Total without Interest</i>	101,670.84										
Sum	107,447.36	10,305.24	10,397.80	10,492.20	10,588.49	10,686.71	10,786.89	10,889.07	10,993.30	11,099.61	11,208.05
Costs	1,197,711.73	117,902.76	118,296.23	118,697.56	119,106.92	119,524.47	119,950.37	120,384.79	120,827.89	121,279.86	121,740.87
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	804,078.05	87,760.02	86,039.23	84,352.19	82,698.22	81,076.69	79,486.95	77,928.38	76,400.38	74,902.33	73,433.66
Application Value 0,002 €/kWh	120,405.53	13,141.50	12,883.82	12,631.20	12,383.53	12,140.71	11,902.66	11,669.28	11,440.47	11,216.14	10,996.22
Additional Market Profits	448,394.11	40,950.28	41,769.28	42,604.67	43,456.76	44,325.90	45,212.42	46,116.66	47,039.00	47,979.78	48,939.37
Sum	1,372,877.70	141,851.79	140,692.34	139,588.06	138,538.52	137,543.30	136,602.03	135,714.32	134,879.84	134,098.25	133,369.25
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	23,949.03	22,396.11	20,890.50	19,431.59	18,018.83	16,651.66	15,329.53	14,051.95	12,818.39	11,628.38	10,488.38
Return on Investment		2%	2%	2%	2%	2%	2%	1%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.019

Variant 2-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	675		
CHP 1 [kWel]	750	4,146	3,109,500
CHP 2 (additional CHP) [kWel]	750	4,614	3,460,500
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	63.57		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	604,253.35	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	63,750.00	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	60,000.00	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59
Investment Total without Interest	831,354.67										
Sum	925,518.29	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83	92,551.83
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		637.50	650.25	663.26	676.52	690.05	703.85	717.93	732.29	746.93	761.87
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		600.00	612.00	624.24	636.72	649.46	662.45	675.70	689.21	703.00	717.06
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	120,426.53	10,998.14	11,218.10	11,442.46	11,671.31	11,904.74	12,142.83	12,385.69	12,633.40	12,886.07	13,143.79
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	50,670.84	4,627.59	4,720.14	4,814.55	4,910.84	5,009.05	5,109.23	5,211.42	5,315.65	5,421.96	5,530.40
Other Costs Total without Interest	101,670.84										
Sum	107,447.36	10,305.24	10,397.80	10,492.20	10,588.49	10,686.71	10,786.89	10,889.07	10,993.30	11,099.61	11,208.05
Costs	1,197,707.51	117,902.37	118,295.83	118,697.16	119,106.51	119,524.05	119,949.95	120,384.35	120,827.45	121,279.41	121,740.41
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	803,986.27	87,750.00	86,029.41	84,342.56	82,688.78	81,067.44	79,477.88	77,919.49	76,391.66	74,893.78	73,425.27
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	522,020.58	47,674.33	48,627.81	49,600.37	50,592.38	51,604.23	52,636.31	53,689.04	54,762.82	55,858.07	56,975.23
Sum	1,446,398.65	148,564.33	147,539.58	146,572.69	145,663.28	144,810.99	144,015.49	143,276.47	142,593.63	141,966.72	141,395.47
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		30,661.95	29,243.75	27,875.53	26,556.76	25,286.94	24,065.55	22,892.11	21,766.18	20,687.31	19,655.06
Return on Investment		3%	3%	3%	3%	2%	2%	2%	2%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.019

Appendix

Variant 2-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	675		
CHP 1 [kWel]	750	4,380	3,285,000
CHP 2 (additional CHP) [kWel]	750	4,380	3,285,000
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	44.92		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	604,253.35	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Control System	63,750.00	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07
Transformer / Grid	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
#BEZUG!	60,000.00	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59
Sum	869,836.21										
Supply Costs	968,358.45	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		637.50	650.25	663.26	676.52	690.05	703.85	717.93	732.29	746.93	761.87
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		600.00	612.00	624.24	636.72	649.46	662.45	675.70	689.21	703.00	717.06
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	133,067.40	12,152.58	12,395.63	12,643.55	12,896.42	13,154.35	13,417.43	13,685.78	13,959.50	14,238.69	14,523.46
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	53,016.27	4,841.79	4,938.63	5,037.40	5,138.15	5,240.91	5,345.73	5,452.64	5,561.70	5,672.93	5,786.39
Other Costs Total without Interest	104,016.27										
Sum	109,792.80	10,519.45	10,616.28	10,715.05	10,815.80	10,918.56	11,023.38	11,130.30	11,239.35	11,350.58	11,464.04
Costs	1,255,533.97	123,555.04	123,975.87	124,405.12	124,842.95	125,289.54	125,745.06	126,209.69	126,683.61	127,167.02	127,660.09
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	803,986.27	87,750.00	86,029.41	84,342.56	82,688.78	81,067.44	79,477.88	77,919.49	76,391.66	74,893.78	73,425.27
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	368,866.05	33,687.26	34,361.00	35,048.22	35,749.19	36,464.17	37,193.45	37,937.32	38,696.07	39,469.99	40,259.39
Sum	1,293,244.12	134,577.26	133,272.77	132,020.54	130,820.09	129,670.93	128,572.63	127,524.75	126,526.88	125,578.63	124,679.63
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		11,022.22	9,296.90	7,615.42	5,977.14	4,381.40	2,827.58	1,315.06	-156.73	-1,588.38	-2,980.46
Return on Investment		1%	1%	1%	1%	0%	0%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019

Variant 2-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	675		
CHP 1 [kWel]	750	4,225	3,168,750
CHP 2 (additional CHP) [kWel]	750	4,537	3,402,750
Total Electricity Production [kWhel/a]	6,571,500		
Additional Earnings Electricity Market [€/kWel; rated a]	62.06		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	604,253.35	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	63,750.00	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	60,000.00	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59
Investment Total without Interest	869,836.21										
Sum	968,358.45	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.87	3,443.39	3,512.25	3,582.50	3,654.15	3,727.23	3,801.78	3,877.81	3,955.37	4,034.47
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		637.50	650.25	663.26	676.52	690.05	703.85	717.93	732.29	746.93	761.87
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		600.00	612.00	624.24	636.72	649.46	662.45	675.70	689.21	703.00	717.06
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	133,075.83	12,153.35	12,396.42	12,644.35	12,897.24	13,155.18	13,418.28	13,686.65	13,960.38	14,239.59	14,524.38
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	53,016.27	4,841.79	4,938.63	5,037.40	5,138.15	5,240.91	5,345.73	5,452.64	5,561.70	5,672.93	5,786.39
Other Costs Total without Interest	104,016.27										
Sum	109,792.80	10,519.45	10,616.28	10,715.05	10,815.80	10,918.56	11,023.38	11,130.30	11,239.35	11,350.58	11,464.04
Costs	1,255,542.41	123,555.81	123,976.65	124,405.92	124,843.77	125,290.37	125,745.91	126,210.56	126,684.50	127,167.92	127,661.01
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	804,169.83	87,770.03	86,049.05	84,361.82	82,707.66	81,085.94	79,496.02	77,937.28	76,409.10	74,910.88	73,442.04
Application Value 0,002 €/kWh	120,419.28	13,143.00	12,885.29	12,632.64	12,384.94	12,142.10	11,904.02	11,670.61	11,441.77	11,217.42	10,997.47
Additional Market Profits	509,645.76	46,544.18	47,475.06	48,424.56	49,393.05	50,380.91	51,388.53	52,416.30	53,464.63	54,533.92	55,624.60
Sum	1,434,234.87	147,457.21	146,409.41	145,419.02	144,485.66	143,608.96	142,788.58	142,024.19	141,315.50	140,662.23	140,064.11
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		23,901.40	22,432.75	21,013.10	19,641.89	18,318.59	17,042.67	15,813.63	14,631.00	13,494.31	12,403.11
Return on Investment		2%	2%	2%	2%	2%	2%	1%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019

Appendix

Variant 2-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	675		
CHP 1 [kWel]	750	4,275	3,206,250
CHP 2 (additional CHP) [kWel]	750	4,485	3,363,750
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	71.98		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	604,253.35	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43	67,269.43
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	63,750.00	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07	7,097.07
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	60,000.00	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59	6,679.59
<i>Investment Total without Interest</i>	869,836.21										
Sum	968,358.45	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85	96,835.85
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		637.50	650.25	663.26	676.52	690.05	703.85	717.93	732.29	746.93	761.87
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		600.00	612.00	624.24	636.72	649.46	662.45	675.70	689.21	703.00	717.06
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	133,067.40	12,152.58	12,395.63	12,643.55	12,896.42	13,154.35	13,417.43	13,685.78	13,959.50	14,238.69	14,523.46
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	53,016.27	4,841.79	4,938.63	5,037.40	5,138.15	5,240.91	5,345.73	5,452.64	5,561.70	5,672.93	5,786.39
<i>Other Costs Total without Interest</i>	104,016.27										
Sum	109,792.80	10,519.45	10,616.28	10,715.05	10,815.80	10,918.56	11,023.38	11,130.30	11,239.35	11,350.58	11,464.04
Costs	1,255,533.97	123,555.04	123,975.87	124,405.12	124,842.95	125,289.54	125,745.06	126,209.69	126,683.61	127,167.02	127,660.09
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	803,986.27	87,750.00	86,029.41	84,342.56	82,688.78	81,067.44	79,477.88	77,919.49	76,391.66	74,893.78	73,425.27
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	591,139.58	53,986.73	55,066.46	56,167.79	57,291.14	58,436.97	59,605.71	60,797.82	62,013.78	63,254.05	64,519.13
Sum	1,515,517.64	154,876.73	153,978.22	153,140.11	152,362.04	151,643.73	150,984.89	150,385.25	149,844.59	149,362.70	148,939.37
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	31,321.69	30,002.36	28,734.99	27,519.10	26,354.19	25,239.83	24,175.56	23,160.98	22,195.68	21,279.29	20,360.00
Return on Investment		3%	3%	3%	3%	3%	2%	2%	2%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019	0.019

Variant 3-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	2,250		
Padditional [kWel]	1,425		
CHP 1 [kWel]	750	4,380	3,285,000
CHP 2 (additional CHP) [kWel]	1,500	2,190	3,285,000
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	52.64		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	964,748.94	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	127,500.00	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	120,000.00	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18
Investment Total without Interest	1,226,248.94										
Sum	1,365,140.37	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		1,275.00	1,300.50	1,326.51	1,353.04	1,380.10	1,407.70	1,435.86	1,464.57	1,493.87	1,523.74
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,200.00	1,224.00	1,248.48	1,273.45	1,298.92	1,324.90	1,351.39	1,378.42	1,405.99	1,434.11
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	104,625.65	9,555.10	9,746.20	9,941.12	10,139.95	10,342.74	10,549.60	10,760.59	10,975.80	11,195.32	11,419.23
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	74,739.53	6,825.70	6,962.22	7,101.46	7,243.49	7,388.36	7,536.13	7,686.85	7,840.59	7,997.40	8,157.35
Other Costs Total without Interest	125,739.53										
Sum	131,516.06	12,503.35	12,639.87	12,779.11	12,921.14	13,066.01	13,213.78	13,364.50	13,518.24	13,675.05	13,835.00
Costs	1,645,597.40	162,619.65	163,028.21	163,444.94	163,870.01	164,303.57	164,745.81	165,196.90	165,657.00	166,126.31	166,605.00
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,339,977.12	146,250.00	143,382.35	140,570.93	137,814.64	135,112.39	132,463.13	129,865.81	127,319.43	124,822.97	122,375.46
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	432,291.14	39,479.65	40,269.24	41,074.63	41,896.12	42,734.04	43,588.72	44,460.50	45,349.71	46,256.70	47,181.83
Sum	1,892,660.04	198,869.65	196,533.95	194,275.32	192,092.88	189,985.76	187,953.16	185,994.26	184,108.29	182,294.53	180,552.26
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		36,249.99	33,505.73	30,830.37	28,222.87	25,682.19	23,207.34	20,797.36	18,451.29	16,168.23	13,947.26
Return on Investment		2%	2%	2%	2%	2%	2%	1%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025

Appendix

Variant 3-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	2,250		
Padditional [kWel]	1,425		
CHP 1 [kWel]	750	4,277	3,207,750
CHP 2 (additional CHP) [kWel]	1,500	2,242	3,363,000
Total Electricity Production [kWhel/a]	6,570,750		
Additional Earnings Electricity Market [€/kWel; rated a]	56.84		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	964,748.94	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	127,500.00	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	120,000.00	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18
Investment Total without Interest	1,226,248.94										
Sum	1,365,140.37	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.48	3,442.99	3,511.85	3,582.09	3,653.73	3,726.81	3,801.34	3,877.37	3,954.92	4,034.01
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		1,275.00	1,300.50	1,326.51	1,353.04	1,380.10	1,407.70	1,435.86	1,464.57	1,493.87	1,523.74
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,200.00	1,224.00	1,248.48	1,273.45	1,298.92	1,324.90	1,351.39	1,378.42	1,405.99	1,434.11
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	104,629.87	9,555.48	9,746.59	9,941.52	10,140.35	10,343.16	10,550.02	10,761.03	10,976.25	11,195.77	11,419.69
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	74,739.53	6,825.70	6,962.22	7,101.46	7,243.49	7,388.36	7,536.13	7,686.85	7,840.59	7,997.40	8,157.35
Other Costs Total without Interest	125,739.53										
Sum	131,516.06	12,503.35	12,639.87	12,779.11	12,921.14	13,066.01	13,213.78	13,364.50	13,518.24	13,675.05	13,835.00
Costs											
	1,645,601.62	162,620.04	163,028.61	163,445.34	163,870.42	164,303.99	164,746.24	165,197.33	165,657.44	166,126.76	166,605.46
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,340,130.08	146,266.70	143,398.72	140,586.98	137,830.37	135,127.82	132,478.25	129,880.64	127,333.96	124,837.22	122,389.43
Application Value 0,002 €/kWh	120,405.53	13,141.50	12,883.82	12,631.20	12,383.53	12,140.71	11,902.66	11,669.28	11,440.47	11,216.14	10,996.22
Additional Market Profits	466,827.44	42,633.73	43,486.40	44,356.13	45,243.25	46,148.12	47,071.08	48,012.50	48,972.75	49,952.21	50,951.25
Sum	1,927,363.05	202,041.92	199,768.95	197,574.31	195,457.16	193,416.65	191,452.00	189,562.42	187,747.18	186,005.57	184,336.90
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	39,421.89	36,740.34	34,128.97	31,586.74	29,112.66	26,705.76	24,365.09	22,089.74	19,878.81	17,731.44	15,578.11
Return on Investment		3%	2%	2%	2%	2%	2%	2%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025

Variant 3-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	2,250		
Padditional [kWel]	1,425		
CHP 1 [kWel]	750	4,246	3,184,500
CHP 2 (additional CHP) [kWel]	1,500	2,257	3,385,500
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	63.81		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	964,748.94	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	127,500.00	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	120,000.00	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18
Investment Total without Interest	1,226,248.94										
Sum	1,365,140.37	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04	136,514.04
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		1,275.00	1,300.50	1,326.51	1,353.04	1,380.10	1,407.70	1,435.86	1,464.57	1,493.87	1,523.74
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,200.00	1,224.00	1,248.48	1,273.45	1,298.92	1,324.90	1,351.39	1,378.42	1,405.99	1,434.11
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	104,625.65	9,555.10	9,746.20	9,941.12	10,139.95	10,342.74	10,549.60	10,760.59	10,975.80	11,195.32	11,419.23
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	74,739.53	6,825.70	6,962.22	7,101.46	7,243.49	7,388.36	7,536.13	7,686.85	7,840.59	7,997.40	8,157.35
Other Costs Total without Interest	125,739.53										
Sum	131,516.06	12,503.35	12,639.87	12,779.11	12,921.14	13,066.01	13,213.78	13,364.50	13,518.24	13,675.05	13,835.00
Costs	1,645,597.40	162,619.65	163,028.21	163,444.94	163,870.01	164,303.57	164,745.81	165,196.90	165,657.00	166,126.31	166,605.00
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,339,977.12	146,250.00	143,382.35	140,570.93	137,814.64	135,112.39	132,463.13	129,865.81	127,319.43	124,822.97	122,375.46
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	524,059.87	47,860.57	48,817.78	49,794.14	50,790.02	51,805.82	52,841.94	53,898.77	54,976.75	56,076.28	57,197.81
Sum	1,984,428.78	207,250.57	205,082.49	202,994.83	200,986.78	199,057.54	197,206.37	195,432.53	193,735.34	192,114.11	190,568.23
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		44,630.91	42,054.27	39,549.88	37,116.77	34,753.97	32,460.56	30,235.64	28,078.34	25,987.81	23,963.23
Return on Investment		3%	3%	3%	2%	2%	2%	2%	2%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025

Appendix

Variant 3-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	2,250		
Padditional [kWel]	1,425		
CHP 1 [kWel]	750	2,920	2,190,000
CHP 2 (additional CHP) [kWel]	1,500	2,920	4,380,000
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	57.46		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	964,748.94	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Control System	127,500.00	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13
Transformer / Grid	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
#BEZUG!	120,000.00	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18
Sum	1,315,600.27										
Supply Costs	1,464,612.10	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		1,275.00	1,300.50	1,326.51	1,353.04	1,380.10	1,407.70	1,435.86	1,464.57	1,493.87	1,523.74
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,200.00	1,224.00	1,248.48	1,273.45	1,298.92	1,324.90	1,351.39	1,378.42	1,405.99	1,434.11
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	133,976.81	12,235.64	12,480.35	12,729.96	12,984.56	13,244.25	13,509.13	13,779.31	14,054.90	14,336.00	14,622.72
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	80,185.47	7,323.06	7,469.52	7,618.91	7,771.29	7,926.72	8,085.25	8,246.96	8,411.89	8,580.13	8,751.74
Other Costs Total without Interest	131,185.47										
Sum	136,962.00	13,000.71	13,147.17	13,296.57	13,448.94	13,604.37	13,762.90	13,924.61	14,089.55	14,257.79	14,429.39
Costs	1,779,866.23	175,744.72	176,216.84	176,698.40	177,189.59	177,690.61	178,201.64	178,722.90	179,254.58	179,796.89	180,350.05
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,339,977.12	146,250.00	143,382.35	140,570.93	137,814.64	135,112.39	132,463.13	129,865.81	127,319.43	124,822.97	122,375.46
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	471,852.86	43,092.68	43,954.54	44,833.63	45,730.30	46,644.91	47,577.80	48,529.36	49,499.95	50,489.95	51,499.75
Sum	1,932,221.77	202,482.68	200,219.24	198,034.32	195,927.06	193,896.63	191,942.24	190,063.12	188,258.53	186,527.78	184,870.17
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		26,737.96	24,002.40	21,335.92	18,737.47	16,206.02	13,740.60	11,340.22	9,003.96	6,730.88	4,520.11
Return on Investment		2%	1%	1%	1%	1%	1%	1%	1%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027

Variant 3-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	2,250		
Padditional [kWel]	1,425		
CHP 1 [kWel]	750	3,130	2,347,500
CHP 2 (additional CHP) [kWel]	1,500	2,816	4,224,000
Total Electricity Production [kWhel/a]	6,571,500		
Additional Earnings Electricity Market [€/kWel; rated a]	69.66		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	964,748.94	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	127,500.00	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	120,000.00	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18
Investment Total without Interest	1,315,600.27										
Sum	1,464,612.10	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.87	3,443.39	3,512.25	3,582.50	3,654.15	3,727.23	3,801.78	3,877.81	3,955.37	4,034.47
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		1,275.00	1,300.50	1,326.51	1,353.04	1,380.10	1,407.70	1,435.86	1,464.57	1,493.87	1,523.74
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,200.00	1,224.00	1,248.48	1,273.45	1,298.92	1,324.90	1,351.39	1,378.42	1,405.99	1,434.11
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	133,985.25	12,236.41	12,481.14	12,730.76	12,985.37	13,245.08	13,509.98	13,780.18	14,055.79	14,336.90	14,623.64
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	80,185.47	7,323.06	7,469.52	7,618.91	7,771.29	7,926.72	8,085.25	8,246.96	8,411.89	8,580.13	8,751.74
Other Costs Total without Interest	131,185.47										
Sum	136,962.00	13,000.71	13,147.17	13,296.57	13,448.94	13,604.37	13,762.90	13,924.61	14,089.55	14,257.79	14,429.39
Costs	1,779,874.67	175,745.50	176,217.63	176,699.20	177,190.41	177,691.44	178,202.49	178,723.77	179,255.46	179,797.80	180,350.97
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,340,283.05	146,283.39	143,415.09	140,603.03	137,846.11	135,143.24	132,493.37	129,895.46	127,348.49	124,851.47	122,403.40
Application Value 0,002 €/kWh	120,419.28	13,143.00	12,885.29	12,632.64	12,384.94	12,142.10	11,904.02	11,670.61	11,441.77	11,217.42	10,997.47
Additional Market Profits	572,087.86	52,246.80	53,291.73	54,357.57	55,444.72	56,553.61	57,684.69	58,838.38	60,015.15	61,215.45	62,439.76
Sum	2,032,790.19	211,673.19	209,592.12	207,593.24	205,675.77	203,838.96	202,082.08	200,404.45	198,805.42	197,284.34	195,840.63
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		35,927.69	33,374.49	30,894.04	28,485.36	26,147.52	23,879.59	21,680.69	19,549.95	17,486.55	15,489.66
Return on Investment		2%	2%	2%	2%	2%	1%	1%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027

Appendix

Variant 3-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	2,250		
Padditional [kWel]	1,425		
CHP 1 [kWel]	750	3,174	2,380,500
CHP 2 (additional CHP) [kWel]	1,500	2,793	4,189,500
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	81.20		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	2694

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	964,748.94	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15
Additional Gas Storage	89,351.32	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17	9,947.17
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	127,500.00	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	120,000.00	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18
<i>Investment Total without Interest</i>	1,315,600.27										
Sum	1,464,612.10	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21	146,461.21
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		2,980.54	3,040.15	3,100.95	3,162.97	3,226.23	3,290.76	3,356.57	3,423.70	3,492.18	3,562.02
Gas Conditioning / Gas Pipe System		1,275.00	1,300.50	1,326.51	1,353.04	1,380.10	1,407.70	1,435.86	1,464.57	1,493.87	1,523.74
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,200.00	1,224.00	1,248.48	1,273.45	1,298.92	1,324.90	1,351.39	1,378.42	1,405.99	1,434.11
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	133,976.81	12,235.64	12,480.35	12,729.96	12,984.56	13,244.25	13,509.13	13,779.31	14,054.90	14,336.00	14,622.72
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	80,185.47	7,323.06	7,469.52	7,618.91	7,771.29	7,926.72	8,085.25	8,246.96	8,411.89	8,580.13	8,751.74
<i>Other Costs Total without Interest</i>	131,185.47										
Sum	136,962.00	13,000.71	13,147.17	13,296.57	13,448.94	13,604.37	13,762.90	13,924.61	14,089.55	14,257.79	14,429.39
Costs	1,779,866.23	175,744.72	176,216.84	176,698.40	177,189.59	177,690.61	178,201.64	178,722.90	179,254.58	179,796.89	180,350.05
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,339,977.12	146,250.00	143,382.35	140,570.93	137,814.64	135,112.39	132,463.13	129,865.81	127,319.43	124,822.97	122,375.46
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	666,835.30	60,899.75	62,117.75	63,360.10	64,627.30	65,919.85	67,238.25	68,583.01	69,954.67	71,353.77	72,780.84
Sum	2,127,204.21	220,289.75	218,382.45	216,560.79	214,824.06	213,171.57	211,602.68	210,116.77	208,713.26	207,391.60	206,151.26
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	44,545.03	42,165.61	39,862.39	37,634.47	35,480.97	33,401.04	31,393.87	29,458.68	27,594.70	25,801.21	24,061.21
Return on Investment		3%	3%	2%	2%	2%	2%	2%	2%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027

Variant 3-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	2,250		
Padditional [kWel]	1,425		
CHP 1 [kWel]	750	2,920	2,190,000
CHP 2 (additional CHP) [kWel]	1,500	2,920	4,380,000
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	57.46		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	964,748.94	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	127,500.00	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	120,000.00	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18
Investment Total without Interest	1,354,081.81										
Sum	1,507,452.26	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		1,275.00	1,300.50	1,326.51	1,353.04	1,380.10	1,407.70	1,435.86	1,464.57	1,493.87	1,523.74
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,200.00	1,224.00	1,248.48	1,273.45	1,298.92	1,324.90	1,351.39	1,378.42	1,405.99	1,434.11
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	146,617.68	13,390.08	13,657.88	13,931.04	14,209.66	14,493.86	14,783.73	15,079.41	15,381.00	15,688.62	16,002.39
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	82,530.91	7,537.26	7,688.01	7,841.77	7,998.60	8,158.57	8,321.75	8,488.18	8,657.94	8,831.10	9,007.72
Other Costs Total without Interest	133,530.91										
Sum	139,307.44	13,214.91	13,365.66	13,519.42	13,676.25	13,836.23	13,999.40	14,165.83	14,335.60	14,508.76	14,685.38
Costs	1,837,692.70	181,397.39	181,896.88	182,406.36	182,926.03	183,456.09	183,996.75	184,548.23	185,110.74	185,684.50	186,269.73
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,339,977.12	146,250.00	143,382.35	140,570.93	137,814.64	135,112.39	132,463.13	129,865.81	127,319.43	124,822.97	122,375.46
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	471,852.86	43,092.68	43,954.54	44,833.63	45,730.30	46,644.91	47,577.80	48,529.36	49,499.95	50,489.95	51,499.75
Sum	1,932,221.77	202,482.68	200,219.24	198,034.32	195,927.06	193,896.63	191,942.24	190,063.12	188,258.53	186,527.78	184,870.17
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		21,085.30	18,322.36	15,627.96	13,001.03	10,440.54	7,945.48	5,514.89	3,147.80	843.28	-1,399.56
Return on Investment		1%	1%	1%	1%	1%	0%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028

Appendix

Variant 3-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	2,250		
Padditional [kWel]	1,425		
CHP 1 [kWel]	750	3,026	2,269,500
CHP 2 (additional CHP) [kWel]	1,500	2,868	4,302,000
Total Electricity Production [kWhel/a]	6,571,500		
Additional Earnings Electricity Market [€/kWel; rated a]	78.29		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	964,748.94	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	127,500.00	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	120,000.00	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18
<i>Investment Total without Interest</i>	1,354,081.81										
Sum	1,507,452.26	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.87	3,443.39	3,512.25	3,582.50	3,654.15	3,727.23	3,801.78	3,877.81	3,955.37	4,034.47
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		1,275.00	1,300.50	1,326.51	1,353.04	1,380.10	1,407.70	1,435.86	1,464.57	1,493.87	1,523.74
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,200.00	1,224.00	1,248.48	1,273.45	1,298.92	1,324.90	1,351.39	1,378.42	1,405.99	1,434.11
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	146,626.11	13,390.85	13,658.67	13,931.84	14,210.48	14,494.69	14,784.58	15,080.28	15,381.88	15,689.52	16,003.31
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	82,530.91	7,537.26	7,688.01	7,841.77	7,998.60	8,158.57	8,321.75	8,488.18	8,657.94	8,831.10	9,007.72
<i>Other Costs Total without Interest</i>	133,530.91										
Sum	139,307.44	13,214.91	13,365.66	13,519.42	13,676.25	13,836.23	13,999.40	14,165.83	14,335.60	14,508.76	14,685.38
Costs											
	1,837,701.13	181,398.16	181,897.66	182,407.16	182,926.85	183,456.92	183,997.61	184,549.10	185,111.62	185,685.40	186,270.65
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,340,283.05	146,283.39	143,415.09	140,603.03	137,846.11	135,143.24	132,493.37	129,895.46	127,348.49	124,851.47	122,403.40
Application Value 0,002 €/kWh	120,419.28	13,143.00	12,885.29	12,632.64	12,384.94	12,142.10	11,904.02	11,670.61	11,441.77	11,217.42	10,997.47
Additional Market Profits	642,929.03	58,716.48	59,890.81	61,088.62	62,310.39	63,556.60	64,827.73	66,124.29	67,446.77	68,795.71	70,171.62
Sum	2,103,631.35	218,142.87	216,191.19	214,324.29	212,541.44	210,841.94	209,225.13	207,690.36	206,237.04	204,864.60	203,572.50
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		36,744.71	34,293.52	31,917.13	29,614.60	27,385.02	25,227.52	23,141.26	21,125.42	19,179.20	17,301.85
Return on Investment		2%	2%	2%	2%	2%	2%	1%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028

Variant 3-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	750		
Installed Capacity [kWel]	2,250		
Padditional [kWel]	1,425		
CHP 1 [kWel]	750	3,052	2,289,000
CHP 2 (additional CHP) [kWel]	1,500	2,854	4,281,000
Total Electricity Production [kWhel/a]	6,570,000		
Additional Earnings Electricity Market [€/kWel; rated a]	92.80		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	8082

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	964,748.94	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15	107,402.15
Additional Gas Storage	127,832.86	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19	14,231.19
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	127,500.00	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13	14,194.13
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	120,000.00	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18	13,359.18
Investment Total without Interest	1,354,081.81										
Sum	1,507,452.26	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23	150,745.23
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		214.66	218.96	223.34	227.80	232.36	237.01	241.75	246.58	251.51	256.54
Sum	44,315.32	4,047.16	4,128.11	4,210.67	4,294.88	4,380.78	4,468.40	4,557.76	4,648.92	4,741.90	4,836.74
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		3,375.10	3,442.60	3,511.45	3,581.68	3,653.31	3,726.38	3,800.91	3,876.93	3,954.46	4,033.55
Rated Power [kWel]		4,134.99	4,217.69	4,302.04	4,388.08	4,475.84	4,565.36	4,656.67	4,749.80	4,844.80	4,941.69
Gas Conditioning / Gas Pipe System		1,275.00	1,300.50	1,326.51	1,353.04	1,380.10	1,407.70	1,435.86	1,464.57	1,493.87	1,523.74
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,200.00	1,224.00	1,248.48	1,273.45	1,298.92	1,324.90	1,351.39	1,378.42	1,405.99	1,434.11
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	146,617.68	13,390.08	13,657.88	13,931.04	14,209.66	14,493.86	14,783.73	15,079.41	15,381.00	15,688.62	16,002.39
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	82,530.91	7,537.26	7,688.01	7,841.77	7,998.60	8,158.57	8,321.75	8,488.18	8,657.94	8,831.10	9,007.72
Other Costs Total without Interest	133,530.91										
Sum	139,307.44	13,214.91	13,365.66	13,519.42	13,676.25	13,836.23	13,999.40	14,165.83	14,335.60	14,508.76	14,685.38
Costs	1,837,692.70	181,397.39	181,896.88	182,406.36	182,926.03	183,456.09	183,996.75	184,548.23	185,110.74	185,684.50	186,269.73
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,339,977.12	146,250.00	143,382.35	140,570.93	137,814.64	135,112.39	132,463.13	129,865.81	127,319.43	124,822.97	122,375.46
Application Value 0,002 €/kWh	120,391.79	13,140.00	12,882.35	12,629.76	12,382.12	12,139.33	11,901.30	11,667.94	11,439.16	11,214.86	10,994.96
Additional Market Profits	762,135.57	69,603.20	70,995.26	72,415.16	73,863.47	75,340.74	76,847.55	78,384.50	79,952.19	81,551.24	83,182.26
Sum	2,222,504.47	228,993.20	227,259.96	225,615.86	224,060.22	222,592.46	221,211.99	219,918.26	218,710.78	217,589.07	216,552.68
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		47,595.81	45,363.09	43,209.50	41,134.20	39,136.37	37,215.23	35,370.03	33,600.04	31,904.57	30,282.95
Return on Investment		3%	3%	3%	2%	2%	2%	2%	2%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028

A.4 $P_{\text{rated}} = 1,000 \text{ kW}_{\text{el}}$

Variant 1.25-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,250		
Padditional [kWel]	150		
CHP 1 [kWel]	1,000	6,935	6,935,000
CHP 2 (additional CHP) [kWel]	250	7,300	1,825,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
<i>Investment Total without Interest</i>	343,097.34										
Sum	381,958.35	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	88,128.86	8,048.50	8,209.47	8,373.66	8,541.14	8,711.96	8,886.20	9,063.92	9,245.20	9,430.10	9,618.71
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	20,911.69	1,909.79	1,947.99	1,986.95	2,026.69	2,067.22	2,108.56	2,150.74	2,193.75	2,237.63	2,282.38
<i>Other Costs Total without Interest</i>	71,911.69										
Sum	77,688.22	7,587.44	7,625.64	7,664.60	7,704.34	7,744.87	7,786.22	7,828.39	7,871.40	7,915.28	7,960.03
Costs	593,262.29	57,985.94	58,268.19	58,556.08	58,849.73	59,149.26	59,454.77	59,766.40	60,084.26	60,408.47	60,739.17
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	178,663.62	19,500.00	19,117.65	18,742.79	18,375.29	18,014.99	17,661.75	17,315.44	16,975.92	16,643.06	16,316.73
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	240,770.45	21,988.73	22,428.50	22,877.07	23,334.61	23,801.31	24,277.33	24,762.88	25,258.14	25,763.30	26,278.57
Sum	579,956.45	59,008.73	58,722.62	58,459.54	58,219.39	58,002.06	57,807.49	57,635.58	57,486.28	57,359.51	57,255.25
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		1,022.79	454.43	-96.54	-630.35	-1,147.19	-1,647.29	-2,130.82	-2,597.98	-3,048.96	-3,483.93
Return on Investment		0%	0%	0%	0%	0%	0%	0%	-1%	-1%	-1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007

Variant 1.25-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,250		
Padditional [kWel]	150		
CHP 1 [kWel]	1,000	7,094	7,094,000
CHP 2 (additional CHP) [kWel]	250	6,675	1,668,750
Total Electricity Production [kWhel/a]	8,762,750		
Additional Earnings Electricity Market [€/kWel; rated a]	23.85		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
Investment Total without Interest	343,097.34										
Sum	381,958.35	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,144.80	4,227.70	4,312.25	4,398.50	4,486.47	4,576.20	4,667.72	4,761.08	4,856.30	4,953.42
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	90,469.92	8,262.30	8,427.55	8,596.10	8,768.02	8,943.38	9,122.25	9,304.70	9,490.79	9,680.61	9,874.22
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	20,911.69	1,909.79	1,947.99	1,986.95	2,026.69	2,067.22	2,108.56	2,150.74	2,193.75	2,237.63	2,282.38
Other Costs Total without Interest	71,911.69										
Sum	77,688.22	7,587.44	7,625.64	7,664.60	7,704.34	7,744.87	7,786.22	7,828.39	7,871.40	7,915.28	7,960.03
Costs	595,603.35	58,199.74	58,486.27	58,778.52	59,076.62	59,380.68	59,690.83	60,007.18	60,329.85	60,658.98	60,994.69
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	178,719.70	19,506.12	19,123.65	18,748.68	18,381.05	18,020.64	17,667.30	17,320.88	16,981.25	16,648.29	16,321.85
Application Value 0,002 €/kWh	160,572.78	17,525.50	17,181.86	16,844.96	16,514.67	16,190.85	15,873.39	15,562.14	15,257.00	14,957.85	14,664.55
Additional Market Profits	261,121.17	23,847.29	24,324.24	24,810.72	25,306.93	25,813.07	26,329.33	26,855.92	27,393.04	27,940.90	28,499.72
Sum	600,413.65	60,878.91	60,629.75	60,404.36	60,202.66	60,024.57	59,870.02	59,738.94	59,631.29	59,547.03	59,486.12
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		2,679.17	2,143.48	1,625.84	1,126.04	643.88	179.19	-268.23	-698.55	-1,111.94	-1,508.56
Return on Investment		1%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007

Appendix

Variant 1.25-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,250		
Padditional [kWel]	150		
CHP 1 [kWel]	1,000	7,070	7,070,000
CHP 2 (additional CHP) [kWel]	250	6,760	1,690,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	26.24		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
<i>Investment Total without Interest</i>	343,097.34										
Sum	381,958.35	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84	38,195.84
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	90,455.67	8,261.00	8,426.22	8,594.75	8,766.64	8,941.98	9,120.81	9,303.23	9,489.30	9,679.08	9,872.66
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	20,911.69	1,909.79	1,947.99	1,986.95	2,026.69	2,067.22	2,108.56	2,150.74	2,193.75	2,237.63	2,282.38
<i>Other Costs Total without Interest</i>	71,911.69										
Sum	77,688.22	7,587.44	7,625.64	7,664.60	7,704.34	7,744.87	7,786.22	7,828.39	7,871.40	7,915.28	7,960.03
Costs	595,589.10	58,198.44	58,484.94	58,777.17	59,075.24	59,379.28	59,689.39	60,005.71	60,328.35	60,657.45	60,993.13
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	178,663.62	19,500.00	19,117.65	18,742.79	18,375.29	18,014.99	17,661.75	17,315.44	16,975.92	16,643.06	16,316.73
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	287,318.06	26,239.76	26,764.56	27,299.85	27,845.84	28,402.76	28,970.82	29,550.23	30,141.24	30,744.06	31,358.94
Sum	626,504.06	63,259.76	63,058.67	62,882.32	62,730.62	62,603.52	62,500.97	62,422.93	62,369.37	62,340.28	62,335.62
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	5,061.32	4,573.73	4,105.15	3,655.38	3,224.24	2,811.58	2,417.22	2,041.02	1,682.82	1,342.49	0%
Return on Investment		1%	1%	1%	1%	1%	1%	1%	0%	0%	0%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007

Variant 1.25-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,250		
Padditional [kWel]	150		
CHP 1 [kWel]	1,000	6,935	6,935,000
CHP 2 (additional CHP) [kWel]	250	7,300	1,825,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
Investment Total without Interest	441,233.94										
Sum	491,210.42	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	122,692.73	11,205.10	11,429.20	11,657.79	11,890.94	12,128.76	12,371.34	12,618.76	12,871.14	13,128.56	13,391.13
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	26,893.09	2,456.05	2,505.17	2,555.28	2,606.38	2,658.51	2,711.68	2,765.91	2,821.23	2,877.66	2,935.21
Other Costs Total without Interest	77,893.09										
Sum	83,669.61	8,133.71	8,182.83	8,232.93	8,284.04	8,336.16	8,389.33	8,443.57	8,498.88	8,555.31	8,612.86
Costs	743,059.63	72,614.01	72,970.31	73,333.74	73,704.44	74,082.56	74,468.24	74,861.63	75,262.89	75,672.17	76,089.64
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	178,663.62	19,500.00	19,117.65	18,742.79	18,375.29	18,014.99	17,661.75	17,315.44	16,975.92	16,643.06	16,316.73
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	240,770.45	21,988.73	22,428.50	22,877.07	23,334.61	23,801.31	24,277.33	24,762.88	25,258.14	25,763.30	26,278.57
Sum	579,956.45	59,008.73	58,722.62	58,459.54	58,219.39	58,002.06	57,807.49	57,635.58	57,486.28	57,359.51	57,255.25
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-13,605.28	-14,247.69	-14,874.20	-15,485.06	-16,080.49	-16,660.75	-17,226.05	-17,776.61	-18,312.66	-18,834.39
Return on Investment		-2%	-2%	-3%	-3%	-3%	-3%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.008	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009

Appendix

Variant 1.25-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,250		
Padditional [kWel]	150		
CHP 1 [kWel]	1,000	7,093	7,093,000
CHP 2 (additional CHP) [kWel]	250	6,675	1,668,750
Total Electricity Production [kWhel/a]	8,761,750		
Additional Earnings Electricity Market [€/kWel; rated a]	26.55		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
<i>Investment Total without Interest</i>	441,233.94										
Sum	491,210.42	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,144.33	4,227.22	4,311.76	4,398.00	4,485.96	4,575.68	4,667.19	4,760.53	4,855.74	4,952.86
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	122,701.79	11,205.93	11,430.05	11,658.65	11,891.82	12,129.66	12,372.25	12,619.70	12,872.09	13,129.53	13,392.12
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	26,893.09	2,456.05	2,505.17	2,555.28	2,606.38	2,658.51	2,711.68	2,765.91	2,821.23	2,877.66	2,935.21
<i>Other Costs Total without Interest</i>	77,893.09										
Sum	83,669.61	8,133.71	8,182.83	8,232.93	8,284.04	8,336.16	8,389.33	8,443.57	8,498.88	8,555.31	8,612.86
Costs	743,068.69	72,614.83	72,971.16	73,334.61	73,705.32	74,083.46	74,469.15	74,862.56	75,263.84	75,673.14	76,090.63
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	178,699.31	19,503.90	19,121.47	18,746.54	18,378.96	18,018.58	17,665.28	17,318.90	16,979.31	16,646.39	16,319.99
Application Value 0,002 €/kWh	160,554.45	17,523.50	17,179.90	16,843.04	16,512.79	16,189.01	15,871.57	15,560.37	15,255.26	14,956.14	14,662.88
Additional Market Profits	290,767.81	26,554.81	27,085.91	27,627.63	28,180.18	28,743.79	29,318.66	29,905.03	30,503.14	31,113.20	31,735.46
Sum	630,021.58	63,582.21	63,387.28	63,217.21	63,071.92	62,951.38	62,855.51	62,784.30	62,737.71	62,715.72	62,718.33
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-9,032.62	-9,583.88	-10,117.40	-10,633.40	-11,132.08	-11,613.64	-12,078.26	-12,526.13	-12,957.42	-13,372.30
Return on Investment		-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%	-2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.008	0.008	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009

Variant 1.25-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,250		
Padditional [kWel]	150		
CHP 1 [kWel]	1,000	7,045	7,045,000
CHP 2 (additional CHP) [kWel]	250	6,860	1,715,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	30.23		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
Investment Total without Interest	441,233.94										
Sum	491,210.42	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04	49,121.04
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	122,692.73	11,205.10	11,429.20	11,657.79	11,890.94	12,128.76	12,371.34	12,618.76	12,871.14	13,128.56	13,391.13
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	26,893.09	2,456.05	2,505.17	2,555.28	2,606.38	2,658.51	2,711.68	2,765.91	2,821.23	2,877.66	2,935.21
Other Costs Total without Interest	77,893.09										
Sum	83,669.61	8,133.71	8,182.83	8,232.93	8,284.04	8,336.16	8,389.33	8,443.57	8,498.88	8,555.31	8,612.86
Costs	743,059.63	72,614.01	72,970.31	73,333.74	73,704.44	74,082.56	74,468.24	74,861.63	75,262.89	75,672.17	76,089.64
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	178,663.62	19,500.00	19,117.65	18,742.79	18,375.29	18,014.99	17,661.75	17,315.44	16,975.92	16,643.06	16,316.73
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	331,006.86	30,229.71	30,834.30	31,450.99	32,080.01	32,721.61	33,376.04	34,043.56	34,724.43	35,418.92	36,127.30
Sum	670,192.87	67,249.71	67,128.42	67,033.46	66,964.78	66,922.37	66,906.19	66,916.26	66,952.57	67,015.13	67,103.98
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-5,364.30	-5,841.89	-6,300.29	-6,739.66	-7,160.19	-7,562.04	-7,945.37	-8,310.32	-8,657.04	-8,985.66
Return on Investment		-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-2%	-2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.008	0.008	0.008	0.008	0.008	0.009	0.009	0.009	0.009	0.009

Appendix

Variant 1.25-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,250		
Padditional [kWel]	150		
CHP 1 [kWel]	1,000	6,935	6,935,000
CHP 2 (additional CHP) [kWel]	250	7,300	1,825,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	21.99		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
<i>Investment Total without Interest</i>	483,499.10										
Sum	538,262.76	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	136,576.48	12,473.06	12,722.52	12,976.97	13,236.51	13,501.24	13,771.26	14,046.69	14,327.62	14,614.17	14,906.46
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	29,469.13	2,691.31	2,745.14	2,800.04	2,856.04	2,913.16	2,971.43	3,030.86	3,091.47	3,153.30	3,216.37
<i>Other Costs Total without Interest</i>	80,469.13										
Sum	86,245.66	8,368.97	8,422.79	8,477.70	8,533.70	8,590.82	8,649.08	8,708.51	8,769.13	8,830.96	8,894.02
Costs	806,571.76	78,822.45	79,208.83	79,602.92	80,004.90	80,414.92	80,833.14	81,259.73	81,694.84	82,138.66	82,591.36
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	178,663.62	19,500.00	19,117.65	18,742.79	18,375.29	18,014.99	17,661.75	17,315.44	16,975.92	16,643.06	16,316.73
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	240,770.45	21,988.73	22,428.50	22,877.07	23,334.61	23,801.31	24,277.33	24,762.88	25,258.14	25,763.30	26,278.57
Sum	579,956.45	59,008.73	58,722.62	58,459.54	58,219.39	58,002.06	57,807.49	57,635.58	57,486.28	57,359.51	57,255.25
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-19,813.73	-20,486.20	-21,143.38	-21,785.52	-22,412.86	-23,025.65	-23,624.15	-24,208.57	-24,779.15	-25,336.11
Return on Investment		-3%	-3%	-3%	-3%	-4%	-4%	-4%	-4%	-4%	-4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009

Variant 1.25-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,250		
Padditional [kWel]	150		
CHP 1 [kWel]	1,000	7,093	7,093,000
CHP 2 (additional CHP) [kWel]	250	6,675	1,668,750
Total Electricity Production [kWhel/a]	8,761,750		
Additional Earnings Electricity Market [€/kWel; rated a]	28.02		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
Investment Total without Interest	483,499.10										
Sum	538,262.76	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,144.33	4,227.22	4,311.76	4,398.00	4,485.96	4,575.68	4,667.19	4,760.53	4,855.74	4,952.86
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	136,585.54	12,473.88	12,723.36	12,977.83	13,237.38	13,502.13	13,772.17	14,047.62	14,328.57	14,615.14	14,907.45
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	29,469.13	2,691.31	2,745.14	2,800.04	2,856.04	2,913.16	2,971.43	3,030.86	3,091.47	3,153.30	3,216.37
Other Costs Total without Interest	80,469.13										
Sum	86,245.66	8,368.97	8,422.79	8,477.70	8,533.70	8,590.82	8,649.08	8,708.51	8,769.13	8,830.96	8,894.02
Costs	806,580.82	78,823.28	79,209.67	79,603.78	80,005.78	80,415.82	80,834.06	81,260.66	81,695.79	82,139.63	82,592.34
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	178,699.31	19,503.90	19,121.47	18,746.54	18,378.96	18,018.58	17,665.28	17,318.90	16,979.31	16,646.39	16,319.99
Application Value 0,002 €/kWh	160,554.45	17,523.50	17,179.90	16,843.04	16,512.79	16,189.01	15,871.57	15,560.37	15,255.26	14,956.14	14,662.88
Additional Market Profits	306,825.82	28,021.34	28,581.76	29,153.40	29,736.47	30,331.20	30,937.82	31,556.58	32,187.71	32,831.46	33,488.09
Sum	646,079.58	65,048.73	64,883.13	64,742.98	64,628.21	64,538.79	64,474.67	64,435.84	64,422.28	64,433.99	64,470.96
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-13,774.55	-14,326.54	-14,860.81	-15,377.57	-15,877.03	-16,359.38	-16,824.82	-17,273.51	-17,705.64	-18,121.39
Return on Investment		-2%	-2%	-2%	-2%	-3%	-3%	-3%	-3%	-3%	-3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009

Appendix

Variant 1.25-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,250		
Padditional [kWel]	150		
CHP 1 [kWel]	1,000	7,012	7,012,000
CHP 2 (additional CHP) [kWel]	250	6,992	1,748,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	33.35		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	287,847.34	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04	32,045.04
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	21,250.00	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69	2,365.69
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	20,000.00	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53	2,226.53
<i>Investment Total without Interest</i>	483,499.10										
Sum	538,262.76	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28	53,826.28
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System		212.50	216.75	221.09	225.51	230.02	234.62	239.31	244.10	248.98	253.96
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		200.00	204.00	208.08	212.24	216.49	220.82	225.23	229.74	234.33	239.02
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	136,576.48	12,473.06	12,722.52	12,976.97	13,236.51	13,501.24	13,771.26	14,046.69	14,327.62	14,614.17	14,906.46
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	29,469.13	2,691.31	2,745.14	2,800.04	2,856.04	2,913.16	2,971.43	3,030.86	3,091.47	3,153.30	3,216.37
<i>Other Costs Total without Interest</i>	80,469.13										
Sum	86,245.66	8,368.97	8,422.79	8,477.70	8,533.70	8,590.82	8,649.08	8,708.51	8,769.13	8,830.96	8,894.02
Costs	806,571.76	78,822.45	79,208.83	79,602.92	80,004.90	80,414.92	80,833.14	81,259.73	81,694.84	82,138.66	82,591.36
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	178,663.62	19,500.00	19,117.65	18,742.79	18,375.29	18,014.99	17,661.75	17,315.44	16,975.92	16,643.06	16,316.73
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	365,227.86	33,354.99	34,022.09	34,702.53	35,396.58	36,104.52	36,826.61	37,563.14	38,314.40	39,080.69	39,862.30
Sum	704,413.86	70,374.99	70,316.21	70,285.00	70,281.36	70,305.27	70,356.76	70,435.84	70,542.54	70,676.90	70,838.98
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	-8,447.46	-8,447.46	-8,447.46	-8,447.46	-8,447.46	-8,447.46	-8,447.46	-8,447.46	-8,447.46	-8,447.46	-8,447.46
Return on Investment		-1%	-1%	-1%	-2%	-2%	-2%	-2%	-2%	-2%	-2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009

Variant 1.5-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	400		
CHP 1 [kWel]	1,000	6,205	6,205,000
CHP 2 (additional CHP) [kWel]	500	5,110	2,555,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	32.18		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	556,076.13										
Sum	619,060.25	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	94,972.43	8,673.50	8,846.97	9,023.91	9,204.39	9,388.48	9,576.25	9,767.77	9,963.13	10,162.39	10,365.64
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	33,892.68	3,095.30	3,157.21	3,220.35	3,284.76	3,350.45	3,417.46	3,485.81	3,555.53	3,626.64	3,699.17
Other Costs Total without Interest	84,892.68										
Sum	90,669.21	8,772.95	8,834.86	8,898.00	8,962.41	9,028.11	9,095.12	9,163.46	9,233.18	9,304.29	9,376.82
Costs	850,188.76	83,506.64	83,825.10	84,149.93	84,481.25	84,819.20	85,163.91	85,515.52	85,874.15	86,239.96	86,613.09
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	476,436.31	52,000.00	50,980.39	49,980.78	49,000.76	48,039.96	47,098.00	46,174.51	45,269.13	44,381.50	43,511.27
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	352,350.16	32,178.92	32,822.49	33,478.94	34,148.52	34,831.49	35,528.12	36,238.69	36,963.46	37,702.73	38,456.78
Sum	989,308.85	101,698.92	100,979.36	100,299.40	99,658.77	99,057.23	98,494.53	97,970.46	97,484.80	97,037.38	96,628.01
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		18,192.28	17,154.26	16,149.47	15,177.52	14,238.03	13,330.62	12,454.94	11,610.65	10,797.42	10,014.92
Return on Investment		3%	2%	2%	2%	2%	2%	2%	2%	2%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010

Appendix

Variant 1.5-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	400		
CHP 1 [kWel]	1,000	6,101	6,100,714
CHP 2 (additional CHP) [kWel]	500	5,319	2,659,285
Total Electricity Production [kWhel/a]	8,759,999		
Additional Earnings Electricity Market [€/kWel; rated a]	35.06		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	556,076.13										
Sum	619,060.25	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	94,972.43	8,673.50	8,846.97	9,023.91	9,204.39	9,388.48	9,576.25	9,767.77	9,963.13	10,162.39	10,365.64
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	33,892.68	3,095.30	3,157.21	3,220.35	3,284.76	3,350.45	3,417.46	3,485.81	3,555.53	3,626.64	3,699.17
Other Costs Total without Interest	84,892.68										
Sum	90,669.21	8,772.95	8,834.86	8,898.00	8,962.41	9,028.11	9,095.12	9,163.46	9,233.18	9,304.29	9,376.82
Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
	850,188.75	83,506.64	83,825.10	84,149.93	84,481.25	84,819.20	85,163.91	85,515.52	85,874.15	86,239.96	86,613.09
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	476,436.27	52,000.00	50,980.39	49,980.77	49,000.76	48,039.96	47,098.00	46,174.51	45,269.13	44,381.50	43,511.27
Application Value 0,002 €/kWh	160,522.37	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	383,930.18	35,063.01	35,764.27	36,479.56	37,209.15	37,953.33	38,712.40	39,486.64	40,276.38	41,081.91	41,903.54
Sum	1,020,888.83	104,583.00	103,921.13	103,300.00	102,719.39	102,179.06	101,678.80	101,218.41	100,797.72	100,416.55	100,074.76
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		21,076.37	20,096.03	19,150.08	18,238.14	17,359.86	16,514.88	15,702.89	14,923.56	14,176.59	13,461.67
Return on Investment		3%	3%	3%	3%	3%	2%	2%	2%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010

Variant 1.5-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	400		
CHP 1 [kWel]	1,000	6,085	6,085,000
CHP 2 (additional CHP) [kWel]	500	5,350	2,675,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	38.25		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Füllstandsüberwachung weiterer Behälter	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
<i>Investment Total without Interest</i>	556,076.13										
Sum	619,060.25	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02	61,906.02
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	94,972.43	8,673.50	8,846.97	9,023.91	9,204.39	9,388.48	9,576.25	9,767.77	9,963.13	10,162.39	10,365.64
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	33,892.68	3,095.30	3,157.21	3,220.35	3,284.76	3,350.45	3,417.46	3,485.81	3,555.53	3,626.64	3,699.17
<i>Other Costs Total without Interest</i>	84,892.68										
Sum	90,669.21	8,772.95	8,834.86	8,898.00	8,962.41	9,028.11	9,095.12	9,163.46	9,233.18	9,304.29	9,376.82
Costs	850,188.76	83,506.64	83,825.10	84,149.93	84,481.25	84,819.20	85,163.91	85,515.52	85,874.15	86,239.96	86,613.09
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	476,436.31	52,000.00	50,980.39	49,980.78	49,000.76	48,039.96	47,098.00	46,174.51	45,269.13	44,381.50	43,511.27
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	418,826.83	38,250.00	39,015.00	39,795.30	40,591.21	41,403.03	42,231.09	43,075.71	43,937.23	44,815.97	45,712.29
Sum	1,055,785.52	107,770.00	107,171.86	106,615.75	106,101.45	105,628.76	105,197.50	104,807.48	104,458.57	104,150.62	103,883.52
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		24,263.36	23,346.76	22,465.83	21,620.20	20,809.56	20,033.58	19,291.97	18,584.42	17,910.66	17,270.43
Return on Investment		3%	3%	3%	3%	3%	3%	3%	3%	3%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010

Appendix

Variant 1.5-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	400		
CHP 1 [kWel]	1,000	5,840	5,840,000
CHP 2 (additional CHP) [kWel]	500	5,475	2,737,500
Total Electricity Production [kWhel/a]	8,577,500		
Additional Earnings Electricity Market [€/kWel; rated a]	32.53		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
<i>Investment Total without Interest</i>	654,212.73										
Sum	728,312.32	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,057.18	4,138.32	4,221.09	4,305.51	4,391.62	4,479.45	4,569.04	4,660.42	4,753.63	4,848.71
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	126,264.27	11,531.28	11,761.90	11,997.14	12,237.08	12,481.83	12,731.46	12,986.09	13,245.81	13,510.73	13,780.94
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	39,874.08	3,641.56	3,714.39	3,788.68	3,864.45	3,941.74	4,020.58	4,100.99	4,183.01	4,266.67	4,352.00
<i>Other Costs Total without Interest</i>	90,874.08										
Sum	96,650.61	9,319.21	9,392.05	9,466.33	9,542.11	9,619.40	9,698.23	9,778.64	9,860.66	9,944.32	10,029.66
Costs	996,714.07	97,835.88	98,222.42	98,616.69	99,018.85	99,429.05	99,847.45	100,274.22	100,709.53	101,153.54	101,606.43
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	466,510.55	50,916.67	49,918.30	48,939.51	47,979.91	47,039.13	46,116.79	45,212.54	44,326.02	43,456.88	42,604.79
Application Value 0,002 €/kWh	157,178.17	17,155.00	16,818.63	16,488.85	16,165.54	15,848.57	15,537.81	15,233.15	14,934.46	14,641.63	14,354.54
Additional Market Profits	356,178.78	32,528.57	33,179.14	33,842.73	34,519.58	35,209.97	35,914.17	36,632.45	37,365.10	38,112.41	38,874.65
Sum	979,867.50	100,600.24	99,916.07	99,271.09	98,665.03	98,097.67	97,568.78	97,078.15	96,625.59	96,210.92	95,833.98
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	2,764.36	1,693.65	1,693.65	1,693.65	-353.82	-1,331.38	-2,278.67	-3,196.08	-4,083.94	-4,942.62	-5,772.46
Return on Investment		0%	0%	0%	0%	0%	0%	0%	0%	-1%	-1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.011	0.011	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012

Variant 1.5-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	400		
CHP 1 [kWel]	1,000	5,892	5,892,140
CHP 2 (additional CHP) [kWel]	500	5,736	2,867,855
Total Electricity Production [kWhel/a]	8,759,995		
Additional Earnings Electricity Market [€/kWel; rated a]	41.68		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	654,212.73										
Sum	728,312.32	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.25	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	127,209.46	11,617.60	11,849.95	12,086.95	12,328.69	12,575.26	12,826.77	13,083.30	13,344.97	13,611.87	13,884.11
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	39,874.08	3,641.56	3,714.39	3,788.68	3,864.45	3,941.74	4,020.58	4,100.99	4,183.01	4,266.67	4,352.00
Other Costs Total without Interest	90,874.08										
Sum	96,650.61	9,319.21	9,392.05	9,466.33	9,542.11	9,619.40	9,698.23	9,778.64	9,860.66	9,944.32	10,029.66
Costs	997,659.25	97,922.20	98,310.47	98,706.50	99,110.45	99,522.48	99,942.76	100,371.43	100,808.68	101,254.68	101,709.60
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	476,436.04	51,999.97	50,980.36	49,980.75	49,000.73	48,039.93	47,097.98	46,174.49	45,269.10	44,381.47	43,511.25
Application Value 0,002 €/kWh	160,522.30	17,519.99	17,176.46	16,839.67	16,509.48	16,185.76	15,868.39	15,557.25	15,252.21	14,953.14	14,659.94
Additional Market Profits	456,412.19	41,682.54	42,516.19	43,366.52	44,233.85	45,118.52	46,020.89	46,941.31	47,880.14	48,837.74	49,814.50
Sum	1,093,370.53	111,202.50	110,673.02	110,186.93	109,744.06	109,344.22	108,987.26	108,673.05	108,401.45	108,172.36	107,985.69
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		13,280.30	12,362.55	11,480.43	10,633.61	9,821.74	9,044.51	8,301.61	7,592.76	6,917.68	6,276.09
Return on Investment		2%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.012	0.012	0.012

Appendix

Variant 1.5-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	400		
CHP 1 [kWel]	1,000	5,890	5,890,000
CHP 2 (additional CHP) [kWel]	500	5,740	2,870,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	45,90		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
<i>Investment Total without Interest</i>	654,212.73										
Sum	728,312.32	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23	72,831.23
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	127,209.49	11,617.60	11,849.95	12,086.95	12,328.69	12,575.26	12,826.77	13,083.31	13,344.97	13,611.87	13,884.11
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	39,874.08	3,641.56	3,714.39	3,788.68	3,864.45	3,941.74	4,020.58	4,100.99	4,183.01	4,266.67	4,352.00
<i>Other Costs Total without Interest</i>	90,874.08										
Sum	96,650.61	9,319.21	9,392.05	9,466.33	9,542.11	9,619.40	9,698.23	9,778.64	9,860.66	9,944.32	10,029.66
Costs											
	997,659.28	97,922.20	98,310.47	98,706.50	99,110.45	99,522.49	99,942.76	100,371.44	100,808.69	101,254.68	101,709.60
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	476,436.31	52,000.00	50,980.39	49,980.78	49,000.76	48,039.96	47,098.00	46,174.51	45,269.13	44,381.50	43,511.27
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	502,571.06	45,898.07	46,816.03	47,752.35	48,707.40	49,681.55	50,675.18	51,688.68	52,722.46	53,776.90	54,852.44
Sum	1,139,529.76	115,418.07	114,972.89	114,572.81	114,217.65	113,907.28	113,641.58	113,420.45	113,243.80	113,111.55	113,023.67
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		17,495.87	16,662.42	15,866.30	15,107.19	14,384.79	13,698.83	13,049.02	12,435.11	11,856.87	11,314.07
Return on Investment		2%	2%	2%	2%	2%	2%	2%	2%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.011	0.011	0.011	0.011	0.011	0.011	0.011	0.012	0.012	0.012

Variant 1.5-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	400		
CHP 1 [kWel]	1,000	5,840	5,840,000
CHP 2 (additional CHP) [kWel]	500	5,475	2,737,500
Total Electricity Production [kWhel/a]	8,577,500		
Additional Earnings Electricity Market [€/kWel; rated a]	32.53		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	696,477.89										
Sum	775,364.65	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,057.18	4,138.32	4,221.09	4,305.51	4,391.62	4,479.45	4,569.04	4,660.42	4,753.63	4,848.71
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System	425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91	517.96
Control System	120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41	146.27
Transformer / Grid	400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04	487.51
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	140,148.02	12,799.23	13,055.22	13,316.32	13,582.65	13,854.30	14,131.39	14,414.01	14,702.29	14,996.34	15,296.27
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	42,450.13	3,876.82	3,954.36	4,033.45	4,114.12	4,196.40	4,280.33	4,365.93	4,453.25	4,542.32	4,633.16
Other Costs Total without Interest	93,450.13										
Sum	99,226.66	9,554.48	9,632.01	9,711.10	9,791.77	9,874.05	9,957.98	10,043.59	10,130.90	10,219.97	10,310.82
Costs	1,060,226.20	104,044.33	104,460.93	104,885.87	105,319.31	105,761.41	106,212.36	106,672.32	107,141.48	107,620.03	108,108.15
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	466,510.55	50,916.67	49,918.30	48,939.51	47,979.91	47,039.13	46,116.79	45,212.54	44,326.02	43,456.88	42,604.79
Application Value 0,002 €/kWh	157,178.17	17,155.00	16,818.63	16,488.85	16,165.54	15,848.57	15,537.81	15,233.15	14,934.46	14,641.63	14,354.54
Additional Market Profits	356,178.78	32,528.57	33,179.14	33,842.73	34,519.58	35,209.97	35,914.17	36,632.45	37,365.10	38,112.41	38,874.65
Sum	979,867.50	100,600.24	99,916.07	99,271.09	98,665.03	98,097.67	97,568.78	97,078.15	96,625.59	96,210.92	95,833.98
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		-3,444.09	-4,544.86	-5,614.78	-6,654.27	-7,663.74	-8,643.58	-9,594.17	-10,515.90	-11,409.11	-12,274.17
Return on Investment		0%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%	-1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.013	0.013

Appendix

Variant 1.5-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	400		
CHP 1 [kWel]	1,000	5,892	5,892,140
CHP 2 (additional CHP) [kWel]	500	5,736	2,867,855
Total Electricity Production [kWhel/a]	8,759,995		
Additional Earnings Electricity Market [€/kWel; rated a]	45.61		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
<i>Investment Total without Interest</i>	696,477.89										
Sum	775,364.65	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.25	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	141,093.21	12,885.55	13,143.26	13,406.13	13,674.25	13,947.74	14,226.69	14,511.23	14,801.45	15,097.48	15,399.43
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	42,450.13	3,876.82	3,954.36	4,033.45	4,114.12	4,196.40	4,280.33	4,365.93	4,453.25	4,542.32	4,633.16
<i>Other Costs Total without Interest</i>	93,450.13										
Sum	99,226.66	9,554.48	9,632.01	9,711.10	9,791.77	9,874.05	9,957.98	10,043.59	10,130.90	10,219.97	10,310.82
Costs	1,061,171.38	104,130.65	104,548.98	104,975.68	105,410.91	105,854.85	106,307.66	106,769.53	107,240.64	107,721.17	108,211.31
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	476,436.04	51,999.97	50,980.36	49,980.75	49,000.73	48,039.93	47,097.98	46,174.49	45,269.10	44,381.47	43,511.25
Application Value 0,002 €/kWh	160,522.30	17,519.99	17,176.46	16,839.67	16,509.48	16,185.76	15,868.39	15,557.25	15,252.21	14,953.14	14,659.94
Additional Market Profits	499,384.61	45,607.06	46,519.20	47,449.59	48,398.58	49,366.55	50,353.88	51,360.96	52,388.18	53,435.94	54,504.66
Sum	1,136,342.94	115,127.02	114,676.03	114,270.00	113,908.79	113,592.25	113,320.25	113,092.69	112,909.49	112,770.56	112,675.85
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		10,996.37	10,127.05	9,294.32	8,497.88	7,737.40	7,012.59	6,323.16	5,668.85	5,049.39	4,464.54
Return on Investment		1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012

Variant 1.5-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	1,500		
Padditional [kWel]	400		
CHP 1 [kWel]	1,000	5,861	5,861,000
CHP 2 (additional CHP) [kWel]	500	5,798	2,899,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	50.17		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	459,576.13	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01	51,163.01
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	42,500.00	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38	4,731.38
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Investment Total without Interest	696,477.89										
Sum	775,364.65	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47	77,536.47
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System		425.00	433.50	442.17	451.01	460.03	469.23	478.62	488.19	497.96	507.91
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		400.00	408.00	416.16	424.48	432.97	441.63	450.46	459.47	468.66	478.04
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	141,093.24	12,885.56	13,143.27	13,406.13	13,674.25	13,947.74	14,226.69	14,511.23	14,801.45	15,097.48	15,399.43
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	42,450.13	3,876.82	3,954.36	4,033.45	4,114.12	4,196.40	4,280.33	4,365.93	4,453.25	4,542.32	4,633.16
Other Costs Total without Interest	93,450.13										
Sum	99,226.66	9,554.48	9,632.01	9,711.10	9,791.77	9,874.05	9,957.98	10,043.59	10,130.90	10,219.97	10,310.82
Costs	1,061,171.41	104,130.65	104,548.98	104,975.68	105,410.91	105,854.85	106,307.66	106,769.53	107,240.64	107,721.17	108,211.31
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	476,436.31	52,000.00	50,980.39	49,980.78	49,000.76	48,039.96	47,098.00	46,174.51	45,269.13	44,381.50	43,511.27
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	549,349.42	50,170.18	51,173.58	52,197.05	53,240.99	54,305.81	55,391.93	56,499.77	57,629.76	58,782.36	59,958.00
Sum	1,186,308.11	119,690.18	119,330.44	119,017.50	118,751.24	118,531.54	118,358.33	118,231.54	118,151.10	118,117.01	118,129.23
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		15,559.52	14,781.46	14,041.82	13,340.33	12,676.70	12,050.67	11,462.00	10,910.46	10,395.83	9,917.92
Return on Investment		2%	2%	2%	2%	1%	1%	1%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012

Appendix

Variant 2-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	2,000		
Padditional [kWel]	900		
CHP 1 [kWel]	1,000	4,015	4,015,000
CHP 2 (additional CHP) [kWel]	1,000	4,745	4,745,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	43.56		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	733,757.77	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	85,000.00	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	80,000.00	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12
Investment Total without Interest	912,757.77										
Sum	1,016,141.53	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		850.00	867.00	884.34	902.03	920.07	938.47	957.24	976.38	995.91	1,015.83
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		800.00	816.00	832.32	848.97	865.95	883.26	900.93	918.95	937.33	956.07
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	104,005.95	9,498.50	9,688.47	9,882.24	10,079.89	10,281.48	10,487.11	10,696.86	10,910.79	11,129.01	11,351.59
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	55,632.33	5,080.71	5,182.32	5,285.97	5,391.69	5,499.52	5,609.51	5,721.70	5,836.14	5,952.86	6,071.92
Other Costs Total without Interest	106,632.33										
Sum	112,408.86	10,758.36	10,859.97	10,963.62	11,069.34	11,177.17	11,287.16	11,399.35	11,513.79	11,630.51	11,749.57
Costs											
	1,278,043.20	126,025.17	126,399.84	126,782.00	127,171.81	127,569.41	127,974.96	128,388.62	128,810.56	129,240.93	129,679.91
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,071,981.69	117,000.00	114,705.88	112,456.75	110,251.71	108,089.91	105,970.50	103,892.65	101,855.54	99,858.37	97,900.37
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	476,933.84	43,556.71	44,427.85	45,316.40	46,222.73	47,147.19	48,090.13	49,051.93	50,032.97	51,033.63	52,054.30
Sum	1,709,437.92	178,076.71	176,310.20	174,612.83	172,983.93	171,422.87	169,929.04	168,501.84	167,140.73	165,845.15	164,614.62
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		52,051.54	49,910.36	47,830.83	45,812.13	43,853.47	41,954.08	40,113.22	38,330.17	36,604.22	34,934.71
Return on Investment		5%	4%	4%	4%	4%	4%	4%	3%	3%	3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.014	0.014	0.014	0.015	0.015	0.015	0.015	0.015	0.015	0.015

Variant 2-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	2,000		
Padditional [kWel]	900		
CHP 1 [kWel]	1,000	3,651	3,651,000
CHP 2 (additional CHP) [kWel]	1,000	5,110	5,110,000
Total Electricity Production [kWhel/a]	8,761,000		
Additional Earnings Electricity Market [€/kWel; rated a]	46.65		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	733,757.77	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	85,000.00	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	80,000.00	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12
Investment Total without Interest	912,757.77										
Sum	1,016,141.53	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.98	4,226.86	4,311.39	4,397.62	4,485.57	4,575.28	4,666.79	4,760.13	4,855.33	4,952.43
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		850.00	867.00	884.34	902.03	920.07	938.47	957.24	976.38	995.91	1,015.83
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		800.00	816.00	832.32	848.97	865.95	883.26	900.93	918.95	937.33	956.07
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	104,011.13	9,498.98	9,688.96	9,882.73	10,080.39	10,282.00	10,487.64	10,697.39	10,911.34	11,129.56	11,352.16
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	55,632.33	5,080.71	5,182.32	5,285.97	5,391.69	5,499.52	5,609.51	5,721.70	5,836.14	5,952.86	6,071.92
Other Costs Total without Interest	106,632.33										
Sum	112,408.86	10,758.36	10,859.97	10,963.62	11,069.34	11,177.17	11,287.16	11,399.35	11,513.79	11,630.51	11,749.57
Costs	1,278,048.38	126,025.65	126,400.32	126,782.49	127,172.31	127,569.92	127,975.48	128,389.15	128,811.10	129,241.49	129,680.48
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,072,104.07	117,013.36	114,718.98	112,469.58	110,264.30	108,102.25	105,982.60	103,904.51	101,867.17	99,869.77	97,911.54
Application Value 0,002 €/kWh	160,540.71	17,522.00	17,178.43	16,841.60	16,511.37	16,187.62	15,870.22	15,559.03	15,253.96	14,954.86	14,661.63
Additional Market Profits	510,843.19	46,653.54	47,586.61	48,538.34	49,509.10	50,499.29	51,509.27	52,539.46	53,590.25	54,662.05	55,755.29
Sum	1,743,487.97	181,188.89	179,484.01	177,849.52	176,284.78	174,789.16	173,362.09	172,003.00	170,711.37	169,486.68	168,328.46
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		55,163.25	53,083.69	51,067.03	49,112.47	47,219.24	45,386.61	43,613.85	41,900.27	40,245.20	38,647.98
Return on Investment		5%	5%	5%	4%	4%	4%	4%	4%	4%	3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.014	0.014	0.014	0.015	0.015	0.015	0.015	0.015	0.015	0.015

Appendix

Variant 2-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	2,000		
Padditional [kWel]	900		
CHP 1 [kWel]	1,000	3,650	3,650,000
CHP 2 (additional CHP) [kWel]	1,000	5,110	5,110,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	52.42		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	733,757.77	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	85,000.00	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	80,000.00	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12
Investment Total without Interest	912,757.77										
Sum	1,016,141.53	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15	101,614.15
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		850.00	867.00	884.34	902.03	920.07	938.47	957.24	976.38	995.91	1,015.83
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		800.00	816.00	832.32	848.97	865.95	883.26	900.93	918.95	937.33	956.07
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	104,005.95	9,498.50	9,688.47	9,882.24	10,079.89	10,281.48	10,487.11	10,696.86	10,910.79	11,129.01	11,351.59
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	55,632.33	5,080.71	5,182.32	5,285.97	5,391.69	5,499.52	5,609.51	5,721.70	5,836.14	5,952.86	6,071.92
Other Costs Total without Interest	106,632.33										
Sum	112,408.86	10,758.36	10,859.97	10,963.62	11,069.34	11,177.17	11,287.16	11,399.35	11,513.79	11,630.51	11,749.57
Costs											
	1,278,043.20	126,025.17	126,399.84	126,782.00	127,171.81	127,569.41	127,974.96	128,388.62	128,810.56	129,240.93	129,679.91
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,071,981.69	117,000.00	114,705.88	112,456.75	110,251.71	108,089.91	105,970.50	103,892.65	101,855.54	99,858.37	97,900.37
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	574,008.76	52,422.23	53,470.67	54,540.08	55,630.89	56,743.50	57,878.37	59,035.94	60,216.66	61,420.99	62,649.41
Sum	1,806,512.84	186,942.23	185,353.02	183,836.51	182,392.09	181,019.19	179,717.28	178,485.85	177,324.42	176,232.52	175,209.73
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		60,917.05	58,953.18	57,054.51	55,220.28	53,449.79	51,742.33	50,097.23	48,513.86	46,991.59	45,529.82
Return on Investment		5%	5%	5%	5%	5%	5%	4%	4%	4%	4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.014	0.014	0.014	0.015	0.015	0.015	0.015	0.015	0.015	0.015

Variant 2-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	2,000		
Padditional [kWel]	900		
CHP 1 [kWel]	1,000	4,380	4,380,000
CHP 2 (additional CHP) [kWel]	1,000	4,380	4,380,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	44.92		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	733,757.77	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	85,000.00	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	80,000.00	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12
Investment Total without Interest	1,010,894.37										
Sum	1,125,393.60	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System	850.00	867.00	884.34	902.03	920.07	938.47	957.24	976.38	995.91	1,015.83	
Control System	120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41	
Transformer / Grid	800.00	816.00	832.32	848.97	865.95	883.26	900.93	918.95	937.33	956.07	
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	136,243.01	12,442.60	12,691.45	12,945.28	13,204.19	13,468.27	13,737.64	14,012.39	14,292.64	14,578.49	14,870.06
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	61,613.73	5,626.97	5,739.51	5,854.30	5,971.38	6,090.81	6,212.63	6,336.88	6,463.62	6,592.89	6,724.75
Other Costs Total without Interest	112,613.73										
Sum	118,390.26	11,304.62	11,417.16	11,531.95	11,649.04	11,768.46	11,890.28	12,014.53	12,141.27	12,270.54	12,402.40
Costs	1,425,513.73	140,440.74	140,885.21	141,338.58	141,801.01	142,272.69	142,753.80	143,244.54	143,745.09	144,255.65	144,776.42
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,071,981.69	117,000.00	114,705.88	112,456.75	110,251.71	108,089.91	105,970.50	103,892.65	101,855.54	99,858.37	97,900.37
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	491,821.41	44,916.34	45,814.67	46,730.96	47,665.58	48,618.89	49,591.27	50,583.10	51,594.76	52,626.65	53,679.19
Sum	1,724,325.49	179,436.34	177,697.02	176,027.39	174,426.78	172,894.58	171,430.18	170,033.01	168,702.51	167,438.18	166,239.50
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		38,995.60	36,811.81	34,688.81	32,625.77	30,621.89	28,676.38	26,788.47	24,957.42	23,182.53	21,463.08
Return on Investment		3%	3%	3%	3%	2%	2%	2%	2%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.017

Appendix

Variant 2-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	2,000		
Padditional [kWel]	900		
CHP 1 [kWel]	1,000	4,068	4,068,000
CHP 2 (additional CHP) [kWel]	1,000	4,693	4,693,000
Total Electricity Production [kWhel/a]	8,761,000		
Additional Earnings Electricity Market [€/kWel; rated a]	54.60		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	733,757.77	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	85,000.00	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	80,000.00	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12
<i>Investment Total without Interest</i>	1,010,894.37										
Sum	1,125,393.60	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.98	4,226.86	4,311.39	4,397.62	4,485.57	4,575.28	4,666.79	4,760.13	4,855.33	4,952.43
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System		850.00	867.00	884.34	902.03	920.07	938.47	957.24	976.38	995.91	1,015.83
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		800.00	816.00	832.32	848.97	865.95	883.26	900.93	918.95	937.33	956.07
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	136,248.19	12,443.07	12,691.94	12,945.77	13,204.69	13,468.78	13,738.16	14,012.92	14,293.18	14,579.04	14,870.62
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	61,613.73	5,626.97	5,739.51	5,854.30	5,971.38	6,090.81	6,212.63	6,336.88	6,463.62	6,592.89	6,724.75
<i>Other Costs Total without Interest</i>	112,613.73										
Sum	118,390.26	11,304.62	11,417.16	11,531.95	11,649.04	11,768.46	11,890.28	12,014.53	12,141.27	12,270.54	12,402.40
Costs	1,425,518.91	140,441.21	140,885.70	141,339.07	141,801.51	142,273.20	142,754.32	143,245.07	143,745.63	144,256.20	144,776.99
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,072,104.07	117,013.36	114,718.98	112,469.58	110,264.30	108,102.25	105,982.60	103,904.51	101,867.17	99,869.77	97,911.54
Application Value 0,002 €/kWh	160,540.71	17,522.00	17,178.43	16,841.60	16,511.37	16,187.62	15,870.22	15,559.03	15,253.96	14,954.86	14,661.63
Additional Market Profits	597,858.82	54,600.37	55,692.38	56,806.23	57,942.35	59,101.20	60,283.22	61,488.88	62,718.66	63,973.04	65,252.50
Sum	1,830,503.60	189,135.73	187,589.79	186,117.41	184,718.02	183,391.07	182,136.04	180,952.43	179,839.79	178,797.67	177,825.66
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	48,694.51	46,704.09	44,778.34	42,916.51	41,117.87	39,381.71	37,707.36	36,094.15	34,541.46	33,048.68	31,599.28
Return on Investment		4%	4%	4%	3%	3%	3%	3%	3%	3%	3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.017

Variant 2-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	2,000		
Padditional [kWel]	900		
CHP 1 [kWel]	1,000	4,146	4,146,000
CHP 2 (additional CHP) [kWel]	1,000	4,614	4,614,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	63.57		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	733,757.77	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	85,000.00	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	80,000.00	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12
Investment Total without Interest	1,010,894.37										
Sum	1,125,393.60	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36	112,539.36
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System		850.00	867.00	884.34	902.03	920.07	938.47	957.24	976.38	995.91	1,015.83
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		800.00	816.00	832.32	848.97	865.95	883.26	900.93	918.95	937.33	956.07
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	136,243.01	12,442.60	12,691.45	12,945.28	13,204.19	13,468.27	13,737.64	14,012.39	14,292.64	14,578.49	14,870.06
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	61,613.73	5,626.97	5,739.51	5,854.30	5,971.38	6,090.81	6,212.63	6,336.88	6,463.62	6,592.89	6,724.75
Other Costs Total without Interest	112,613.73										
Sum	118,390.26	11,304.62	11,417.16	11,531.95	11,649.04	11,768.46	11,890.28	12,014.53	12,141.27	12,270.54	12,402.40
Costs	1,425,513.73	140,440.74	140,885.21	141,338.58	141,801.01	142,272.69	142,753.80	143,244.54	143,745.09	144,255.65	144,776.42
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,071,981.69	117,000.00	114,705.88	112,456.75	110,251.71	108,089.91	105,970.50	103,892.65	101,855.54	99,858.37	97,900.37
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	696,027.45	63,565.77	64,837.09	66,133.83	67,456.50	68,805.63	70,181.75	71,585.38	73,017.09	74,477.43	75,966.98
Sum	1,928,531.53	198,085.77	196,719.44	195,430.25	194,217.70	193,081.32	192,020.65	191,035.29	190,124.84	189,288.96	188,527.30
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		57,645.03	55,834.23	54,091.67	52,416.70	50,808.63	49,266.85	47,790.75	46,379.76	45,033.31	43,750.88
Return on Investment		5%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.016	0.017

Appendix

Variant 2-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	2,000		
Padditional [kWel]	900		
CHP 1 [kWel]	1,000	4,380	4,380,000
CHP 2 (additional CHP) [kWel]	1,000	4,380	4,380,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	44.92		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	733,757.77	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Control System	85,000.00	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75
Transformer / Grid	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
#BEZUG!	80,000.00	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12
Sum	1,053,159.52										
Supply Costs	1,172,445.93	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System		850.00	867.00	884.34	902.03	920.07	938.47	957.24	976.38	995.91	1,015.83
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		800.00	816.00	832.32	848.97	865.95	883.26	900.93	918.95	937.33	956.07
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	150,126.76	13,710.56	13,984.77	14,264.46	14,549.75	14,840.75	15,137.56	15,440.31	15,749.12	16,064.10	16,385.38
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	64,189.78	5,862.23	5,979.47	6,099.06	6,221.05	6,345.47	6,472.38	6,601.82	6,733.86	6,868.54	7,005.91
Other Costs Total without Interest	115,189.78										
Sum	120,966.31	11,539.88	11,657.13	11,776.72	11,898.70	12,023.12	12,150.03	12,279.48	12,411.51	12,546.19	12,683.56
Costs	1,489,025.86	146,649.19	147,123.73	147,607.76	148,101.47	148,605.05	149,118.71	149,642.64	150,177.04	150,722.14	151,278.14
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,071,981.69	117,000.00	114,705.88	112,456.75	110,251.71	108,089.91	105,970.50	103,892.65	101,855.54	99,858.37	97,900.37
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	491,821.41	44,916.34	45,814.67	46,730.96	47,665.58	48,618.89	49,591.27	50,583.10	51,594.76	52,626.65	53,679.19
Sum	1,724,325.49	179,436.34	177,697.02	176,027.39	174,426.78	172,894.58	171,430.18	170,033.01	168,702.51	167,438.18	166,239.50
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		32,787.15	30,573.29	28,419.63	26,325.31	24,289.53	22,311.47	20,390.37	18,525.47	16,716.04	14,961.37
Return on Investment		3%	2%	2%	2%	2%	2%	2%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017

Variant 2-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	2,000		
Padditional [kWel]	900		
CHP 1 [kWel]	1,000	4,225	4,225,000
CHP 2 (additional CHP) [kWel]	1,000	4,537	4,537,000
Total Electricity Production [kWhel/a]	8,762,000		
Additional Earnings Electricity Market [€/kWel; rated a]	62.06		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	733,757.77	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	85,000.00	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	80,000.00	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12
<i>Investment Total without Interest</i>	1,053,159.52										
Sum	1,172,445.93	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,144.45	4,227.34	4,311.88	4,398.12	4,486.08	4,575.81	4,667.32	4,760.67	4,855.88	4,953.00
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System	850.00	867.00	884.34	902.03	920.07	938.47	957.24	976.38	995.91	1,015.83	
Control System	120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41	
Transformer / Grid	800.00	816.00	832.32	848.97	865.95	883.26	900.93	918.95	937.33	956.07	
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	150,137.12	13,711.50	13,985.73	14,265.45	14,550.76	14,841.77	15,138.61	15,441.38	15,750.21	16,065.21	16,386.51
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	64,189.78	5,862.23	5,979.47	6,099.06	6,221.05	6,345.47	6,472.38	6,601.82	6,733.86	6,868.54	7,005.91
<i>Other Costs Total without Interest</i>	115,189.78										
Sum	120,966.31	11,539.88	11,657.13	11,776.72	11,898.70	12,023.12	12,150.03	12,279.48	12,411.51	12,546.19	12,683.56
Costs	1,489,036.22	146,650.13	147,124.69	147,608.74	148,102.47	148,606.08	149,119.75	149,643.70	150,178.13	150,723.25	151,279.27
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,072,226.44	117,026.71	114,732.07	112,482.42	110,276.88	108,114.59	105,994.70	103,916.37	101,878.80	99,881.17	97,922.72
Application Value 0,002 €/kWh	160,559.04	17,524.00	17,180.39	16,843.52	16,513.26	16,189.47	15,872.03	15,560.81	15,255.70	14,956.57	14,663.30
Additional Market Profits	679,527.68	62,058.90	63,300.08	64,566.08	65,857.40	67,174.55	68,518.04	69,888.40	71,286.17	72,711.90	74,166.13
Sum	1,912,313.15	196,609.62	195,212.54	193,892.03	192,647.55	191,478.61	190,384.77	189,365.59	188,420.67	187,549.63	186,752.15
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		49,959.48	48,087.85	46,283.29	44,545.08	42,872.54	41,265.02	39,721.88	38,242.53	36,826.39	35,472.88
Return on Investment		4%	4%	4%	3%	3%	3%	3%	3%	3%	3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017

Appendix

Variant 2-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	2,000		
Padditional [kWel]	900		
CHP 1 [kWel]	1,000	4,275	4,275,000
CHP 2 (additional CHP) [kWel]	1,000	4,485	4,485,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	71.98		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	733,757.77	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70	81,686.70
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	85,000.00	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75	9,462.75
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	80,000.00	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12	8,906.12
<i>Investment Total without Interest</i>	1,053,159.52										
Sum	1,172,445.93	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59	117,244.59
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System		850.00	867.00	884.34	902.03	920.07	938.47	957.24	976.38	995.91	1,015.83
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		800.00	816.00	832.32	848.97	865.95	883.26	900.93	918.95	937.33	956.07
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	150,126.76	13,710.56	13,984.77	14,264.46	14,549.75	14,840.75	15,137.56	15,440.31	15,749.12	16,064.10	16,385.38
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	64,189.78	5,862.23	5,979.47	6,099.06	6,221.05	6,345.47	6,472.38	6,601.82	6,733.86	6,868.54	7,005.91
<i>Other Costs Total without Interest</i>	115,189.78										
Sum	120,966.31	11,539.88	11,657.13	11,776.72	11,898.70	12,023.12	12,150.03	12,279.48	12,411.51	12,546.19	12,683.56
Costs	1,489,025.86	146,649.19	147,123.73	147,607.76	148,101.47	148,605.05	149,118.71	149,642.64	150,177.04	150,722.14	151,278.14
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,071,981.69	117,000.00	114,705.88	112,456.75	110,251.71	108,089.91	105,970.50	103,892.65	101,855.54	99,858.37	97,900.37
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	788,186.10	71,982.30	73,421.95	74,890.38	76,388.19	77,915.96	79,474.28	81,063.76	82,685.04	84,338.74	86,025.51
Sum	2,020,690.18	206,502.30	205,304.30	204,186.81	203,149.39	202,191.64	201,313.18	200,513.67	199,792.79	199,150.26	198,585.83
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	59,853.11	58,180.57	56,579.05	55,047.93	53,586.59	52,194.48	50,871.03	49,615.75	48,428.12	47,307.69	46,249.48
Return on Investment		5%	4%	4%	4%	4%	4%	4%	4%	4%	4%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017	0.017

Variant 3-1-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	3,000		
Padditional [kWel]	1,900		
CHP 1 [kWel]	1,000	4,380	4,380,000
CHP 2 (additional CHP) [kWel]	2,000	2,190	4,380,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	52.64		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	1,171,515.28	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	170,000.00	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	160,000.00	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24
Investment Total without Interest	1,515,515.28										
Sum	1,687,170.54	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		1,700.00	1,734.00	1,768.68	1,804.05	1,840.13	1,876.94	1,914.48	1,952.77	1,991.82	2,031.66
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,600.00	1,632.00	1,664.64	1,697.93	1,731.89	1,766.53	1,801.86	1,837.90	1,874.66	1,912.15
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	122,072.99	11,148.50	11,371.47	11,598.90	11,830.88	12,067.50	12,308.85	12,555.02	12,806.13	13,062.25	13,323.49
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	92,370.23	8,435.85	8,604.57	8,776.66	8,952.19	9,131.24	9,313.86	9,500.14	9,690.14	9,883.95	10,081.62
Other Costs Total without Interest	143,370.23										
Sum	149,146.76	14,113.51	14,282.22	14,454.31	14,629.85	14,808.89	14,991.52	15,177.79	15,367.80	15,561.60	15,759.28
Costs	2,003,877.16	198,133.22	198,607.99	199,092.26	199,586.21	200,090.04	200,603.94	201,128.13	201,662.80	202,208.16	202,764.43
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,786,636.16	195,000.00	191,176.47	187,427.91	183,752.86	180,149.86	176,617.51	173,154.42	169,759.23	166,430.62	163,167.28
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	576,388.18	52,639.53	53,692.32	54,766.17	55,861.49	56,978.72	58,118.30	59,280.66	60,466.28	61,675.60	62,909.11
Sum	2,523,546.73	265,159.53	262,045.26	259,033.76	256,123.83	253,314.35	250,604.21	247,992.34	245,477.72	243,059.37	240,736.34
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		67,026.31	63,437.27	59,941.50	56,537.63	53,224.32	50,000.26	46,864.21	43,814.93	40,851.22	37,971.91
Return on Investment		4%	3%	3%	3%	3%	3%	3%	2%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023

Appendix

Variant 3-2-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	3,000		
Padditional [kWel]	1,900		
CHP 1 [kWel]	1,000	4,277	4,277,000
CHP 2 (additional CHP) [kWel]	2,000	2,242	4,484,000
Total Electricity Production [kWhel/a]	8,761,000		
Additional Earnings Electricity Market [€/kWel; rated a]	56.84		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	1,171,515.28	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	170,000.00	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	160,000.00	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24
Investment Total without Interest	1,515,515.28										
Sum	1,687,170.54	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.98	4,226.86	4,311.39	4,397.62	4,485.57	4,575.28	4,666.79	4,760.13	4,855.33	4,952.43
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		1,700.00	1,734.00	1,768.68	1,804.05	1,840.13	1,876.94	1,914.48	1,952.77	1,991.82	2,031.66
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,600.00	1,632.00	1,664.64	1,697.93	1,731.89	1,766.53	1,801.86	1,837.90	1,874.66	1,912.15
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	122,078.17	11,148.98	11,371.96	11,599.39	11,831.38	12,068.01	12,309.37	12,555.56	12,806.67	13,062.80	13,324.06
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	92,370.23	8,435.85	8,604.57	8,776.66	8,952.19	9,131.24	9,313.86	9,500.14	9,690.14	9,883.95	10,081.62
Other Costs Total without Interest	143,370.23										
Sum	149,146.76	14,113.51	14,282.22	14,454.31	14,629.85	14,808.89	14,991.52	15,177.79	15,367.80	15,561.60	15,759.28
Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
	2,003,882.34	198,133.69	198,608.47	199,092.75	199,586.71	200,090.55	200,604.47	201,128.66	201,663.34	202,208.71	202,764.99
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,786,840.11	195,022.26	191,198.29	187,449.31	183,773.83	180,170.42	176,637.67	173,174.19	169,778.61	166,449.62	163,185.90
Application Value 0,002 €/kWh	160,540.71	17,522.00	17,178.43	16,841.60	16,511.37	16,187.62	15,870.22	15,559.03	15,253.96	14,954.86	14,661.63
Additional Market Profits	622,436.58	56,844.97	57,981.87	59,141.51	60,324.34	61,530.83	62,761.44	64,016.67	65,297.00	66,602.94	67,935.00
Sum	2,569,817.41	269,389.23	266,358.60	263,432.42	260,609.54	257,888.87	255,269.33	252,749.89	250,329.57	248,007.42	245,782.53
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		71,255.54	67,750.12	64,339.67	61,022.83	57,798.32	54,664.86	51,621.23	48,666.23	45,798.71	43,017.54
Return on Investment		4%		4%		3%		3%		3%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023

Variant 3-3-6

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	3,000		
Padditional [kWel]	1,900		
CHP 1 [kWel]	1,000	4,246	4,246,000
CHP 2 (additional CHP) [kWel]	2,000	2,257	4,514,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	63.81		

Gas Storage	
Gas Storage [h] (6 h existing)	6
Additional Capacity [h]	0
Additional Volume [m³]	0

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	1,171,515.28	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73
Additional Gas Storage	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	170,000.00	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	160,000.00	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24
Investment Total without Interest	1,515,515.28										
Sum	1,687,170.54	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05	168,717.05
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		300.00	306.00	312.12	318.36	324.73	331.22	337.85	344.61	351.50	358.53
Gas Conditioning / Gas Pipe System		1,700.00	1,734.00	1,768.68	1,804.05	1,840.13	1,876.94	1,914.48	1,952.77	1,991.82	2,031.66
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,600.00	1,632.00	1,664.64	1,697.93	1,731.89	1,766.53	1,801.86	1,837.90	1,874.66	1,912.15
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	122,072.99	11,148.50	11,371.47	11,598.90	11,830.88	12,067.50	12,308.85	12,555.02	12,806.13	13,062.25	13,323.49
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	92,370.23	8,435.85	8,604.57	8,776.66	8,952.19	9,131.24	9,313.86	9,500.14	9,690.14	9,883.95	10,081.62
Other Costs Total without Interest	143,370.23										
Sum	149,146.76	14,113.51	14,282.22	14,454.31	14,629.85	14,808.89	14,991.52	15,177.79	15,367.80	15,561.60	15,759.28
Costs	2,003,877.16	198,133.22	198,607.99	199,092.26	199,586.21	200,090.04	200,603.94	201,128.13	201,662.80	202,208.16	202,764.43
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,786,636.16	195,000.00	191,176.47	187,427.91	183,752.86	180,149.86	176,617.51	173,154.42	169,759.23	166,430.62	163,167.28
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	698,746.50	63,814.09	65,090.37	66,392.18	67,720.02	69,074.43	70,455.91	71,865.03	73,302.33	74,768.38	76,263.75
Sum	2,645,905.04	276,334.09	273,443.31	270,659.77	267,982.37	265,410.06	262,941.83	260,576.71	258,313.78	256,152.15	254,090.98
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		78,200.87	74,835.32	71,567.51	68,396.16	65,320.02	62,337.88	59,448.58	56,650.99	53,943.99	51,326.55
Return on Investment		4%	4%	4%	4%	4%	4%	3%	3%	3%	3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023	0.023

Appendix

Variant 3-1-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	3,000		
Padditional [kWel]	1,900		
CHP 1 [kWel]	1,000	2,920	2,920,000
CHP 2 (additional CHP) [kWel]	2,000	2,920	5,840,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	57.46		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	1,171,515.28	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Control System	170,000.00	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51
Transformer / Grid	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
#BEZUG!	160,000.00	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24
Sum	1,613,651.88										
Supply Costs	1,796,422.61	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System		1,700.00	1,734.00	1,768.68	1,804.05	1,840.13	1,876.94	1,914.48	1,952.77	1,991.82	2,031.66
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,600.00	1,632.00	1,664.64	1,697.93	1,731.89	1,766.53	1,801.86	1,837.90	1,874.66	1,912.15
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	154,310.05	14,092.60	14,374.45	14,661.94	14,955.18	15,254.28	15,559.37	15,870.56	16,187.97	16,511.73	16,841.96
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	98,351.63	8,982.11	9,161.76	9,344.99	9,531.89	9,722.53	9,916.98	10,115.32	10,317.62	10,523.98	10,734.46
Other Costs Total without Interest	149,351.63										
Sum	155,128.16	14,659.77	14,839.41	15,022.64	15,209.54	15,400.18	15,594.63	15,792.97	15,995.28	16,201.63	16,412.11
Costs	2,151,347.68	212,548.79	213,093.36	213,648.83	214,215.41	214,793.32	215,382.79	215,984.05	216,597.33	217,222.88	217,860.94
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,786,636.16	195,000.00	191,176.47	187,427.91	183,752.86	180,149.86	176,617.51	173,154.42	169,759.23	166,430.62	163,167.28
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	629,137.15	57,456.91	58,606.05	59,778.17	60,973.73	62,193.21	63,437.07	64,705.81	65,999.93	67,319.93	68,666.33
Sum	2,576,295.69	269,976.91	266,958.99	264,045.76	261,236.08	258,528.84	255,922.98	253,417.49	251,011.38	248,703.70	246,493.56
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		57,428.13	53,865.63	50,396.93	47,020.67	43,735.52	40,540.20	37,433.45	34,414.05	31,480.83	28,632.62
Return on Investment		3%	3%	3%	2%	2%	2%	2%	2%	2%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.025	0.025

Variant 3-2-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	3,000		
Padditional [kWel]	1,900		
CHP 1 [kWel]	1,000	3,130	3,130,000
CHP 2 (additional CHP) [kWel]	2,000	2,816	5,632,000
Total Electricity Production [kWhel/a]	8,762,000		
Additional Earnings Electricity Market [€/kWel; rated a]	69.66		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	1,171,515.28	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	170,000.00	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	160,000.00	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24
Investment Total without Interest	1,613,651.88										
Sum	1,796,422.61	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,144.45	4,227.34	4,311.88	4,398.12	4,486.08	4,575.81	4,667.32	4,760.67	4,855.88	4,953.00
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System		1,700.00	1,734.00	1,768.68	1,804.05	1,840.13	1,876.94	1,914.48	1,952.77	1,991.82	2,031.66
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,600.00	1,632.00	1,664.64	1,697.93	1,731.89	1,766.53	1,801.86	1,837.90	1,874.66	1,912.15
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	154,320.41	14,093.55	14,375.42	14,662.93	14,956.18	15,255.31	15,560.41	15,871.62	16,189.06	16,512.84	16,843.09
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	98,351.63	8,982.11	9,161.76	9,344.99	9,531.89	9,722.53	9,916.98	10,115.32	10,317.62	10,523.98	10,734.46
Other Costs Total without Interest	149,351.63										
Sum	155,128.16	14,659.77	14,839.41	15,022.64	15,209.54	15,400.18	15,594.63	15,792.97	15,995.28	16,201.63	16,412.11
Costs	2,151,358.04	212,549.73	213,094.33	213,649.82	214,216.41	214,794.34	215,383.83	215,985.11	216,598.41	217,223.98	217,862.07
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,787,044.07	195,044.52	191,220.12	187,470.70	183,794.81	180,190.99	176,657.83	173,193.95	169,797.99	166,468.62	163,204.53
Application Value 0,002 €/kWh	160,559.04	17,524.00	17,180.39	16,843.52	16,513.26	16,189.47	15,872.03	15,560.81	15,255.70	14,956.57	14,663.30
Additional Market Profits	762,783.82	69,662.40	71,055.65	72,476.76	73,926.29	75,404.82	76,912.92	78,451.17	80,020.20	81,620.60	83,253.01
Sum	2,710,386.92	282,230.92	279,456.16	276,790.98	274,234.36	271,785.28	269,442.77	267,205.94	265,073.89	263,045.79	261,120.84
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	69,681.19	66,361.83	63,141.17	60,017.94	56,990.93	54,058.94	51,220.83	48,475.47	45,821.80	43,258.78	40,788.91
Return on Investment		4%	3%	3%	3%	3%	3%	3%	2%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.025	0.025

Appendix

Variant 3-3-12

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	3,000		
Padditional [kWel]	1,900		
CHP 1 [kWel]	1,000	3,174	3,174,000
CHP 2 (additional CHP) [kWel]	2,000	2,793	5,586,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	81.20		

Gas Storage	
Gas Storage [h] (6 h existing)	12
Additional Capacity [h]	6
Additional Volume [m³]	3592

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	1,171,515.28	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73
Additional Gas Storage	98,136.60	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21	10,925.21
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	170,000.00	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	160,000.00	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24
<i>Investment Total without Interest</i>	1,613,651.88										
Sum	1,796,422.61	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26	179,642.26
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		3,244.10	3,308.98	3,375.16	3,442.66	3,511.52	3,581.75	3,653.38	3,726.45	3,800.98	3,877.00
Gas Conditioning / Gas Pipe System		1,700.00	1,734.00	1,768.68	1,804.05	1,840.13	1,876.94	1,914.48	1,952.77	1,991.82	2,031.66
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,600.00	1,632.00	1,664.64	1,697.93	1,731.89	1,766.53	1,801.86	1,837.90	1,874.66	1,912.15
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	154,310.05	14,092.60	14,374.45	14,661.94	14,955.18	15,254.28	15,559.37	15,870.56	16,187.97	16,511.73	16,841.96
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	98,351.63	8,982.11	9,161.76	9,344.99	9,531.89	9,722.53	9,916.98	10,115.32	10,317.62	10,523.98	10,734.46
<i>Other Costs Total without Interest</i>	149,351.63										
Sum	155,128.16	14,659.77	14,839.41	15,022.64	15,209.54	15,400.18	15,594.63	15,792.97	15,995.28	16,201.63	16,412.11
Costs	2,151,347.68	212,548.79	213,093.36	213,648.83	214,215.41	214,793.32	215,382.79	215,984.05	216,597.33	217,222.88	217,860.94
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,786,636.16	195,000.00	191,176.47	187,427.91	183,752.86	180,149.86	176,617.51	173,154.42	169,759.23	166,430.62	163,167.28
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	889,113.73	81,199.67	82,823.66	84,480.14	86,169.74	87,893.13	89,651.00	91,444.02	93,272.90	95,138.36	97,041.12
Sum	2,836,272.28	293,719.67	291,176.60	288,747.73	286,432.08	284,228.76	282,136.91	280,155.69	278,284.35	276,522.13	274,868.35
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	81,170.88	78,083.24	75,098.89	72,216.67	69,435.44	66,754.12	64,171.65	61,687.02	59,299.25	57,007.42	54,868.35
Return on Investment		4%	4%	4%	4%	4%	4%	3%	3%	3%	3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.024	0.024	0.024	0.024	0.025	0.025	0.025	0.025	0.025	0.025

Variant 3-1-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	3,000		
Padditional [kWel]	1,900		
CHP 1 [kWel]	1,000	2,920	2,920,000
CHP 2 (additional CHP) [kWel]	2,000	2,920	5,840,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	57.46		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	1,171,515.28	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	170,000.00	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	160,000.00	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24
Investment Total without Interest	1,655,917.04										
Sum	1,843,474.94	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System		1,700.00	1,734.00	1,768.68	1,804.05	1,840.13	1,876.94	1,914.48	1,952.77	1,991.82	2,031.66
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,600.00	1,632.00	1,664.64	1,697.93	1,731.89	1,766.53	1,801.86	1,837.90	1,874.66	1,912.15
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	168,193.80	15,360.56	15,667.77	15,981.12	16,300.74	16,626.76	16,959.29	17,298.48	17,644.45	17,997.34	18,357.29
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	100,927.68	9,217.37	9,401.72	9,589.76	9,781.55	9,977.18	10,176.73	10,380.26	10,587.87	10,799.62	11,015.62
Other Costs Total without Interest	151,927.68										
Sum	157,704.21	14,895.03	15,079.38	15,267.41	15,459.20	15,654.84	15,854.38	16,057.91	16,265.52	16,477.28	16,693.27
Costs	2,214,859.81	218,757.23	219,331.88	219,918.01	220,515.87	221,125.68	221,747.69	222,382.14	223,029.28	223,689.37	224,362.65
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,786,636.16	195,000.00	191,176.47	187,427.91	183,752.86	180,149.86	176,617.51	173,154.42	169,759.23	166,430.62	163,167.28
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	629,137.15	57,456.91	58,606.05	59,778.17	60,973.73	62,193.21	63,437.07	64,705.81	65,999.93	67,319.93	68,666.33
Sum	2,576,295.69	269,976.91	266,958.99	264,045.76	261,236.08	258,528.84	255,922.98	253,417.49	251,011.38	248,703.70	246,493.56
Profit/Losses		€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum		51,219.68	47,627.11	44,127.75	40,720.21	37,403.16	34,175.29	31,035.35	27,982.10	25,014.34	22,130.91
Return on Investment		3%	2%	2%	2%	2%	2%	2%	1%	1%	1%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.026	0.026

Appendix

Variant 3-2-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000	3,026	3,026,000
Installed Capacity [kWel]	3,000		
Padditional [kWel]	1,900		
CHP 1 [kWel]	1,000	3,026	3,026,000
CHP 2 (additional CHP) [kWel]	2,000	2,868	5,736,000
Total Electricity Production [kWhel/a]	8,762,000		
Additional Earnings Electricity Market [€/kWel; rated a]	78.29		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	1,171,515.28	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	170,000.00	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	160,000.00	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24
<i>Investment Total without Interest</i>	1,655,917.04										
Sum	1,843,474.94	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,144.45	4,227.34	4,311.88	4,398.12	4,486.08	4,575.81	4,667.32	4,760.67	4,855.88	4,953.00
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System		1,700.00	1,734.00	1,768.68	1,804.05	1,840.13	1,876.94	1,914.48	1,952.77	1,991.82	2,031.66
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,600.00	1,632.00	1,664.64	1,697.93	1,731.89	1,766.53	1,801.86	1,837.90	1,874.66	1,912.15
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	168,204.16	15,361.50	15,668.73	15,982.11	16,301.75	16,627.78	16,960.34	17,299.55	17,645.54	17,998.45	18,358.42
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Offical Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	100,927.68	9,217.37	9,401.72	9,589.76	9,781.55	9,977.18	10,176.73	10,380.26	10,587.87	10,799.62	11,015.62
<i>Other Costs Total without Interest</i>	151,927.68										
Sum	157,704.21	14,895.03	15,079.38	15,267.41	15,459.20	15,654.84	15,854.38	16,057.91	16,265.52	16,477.28	16,693.27
Costs	2,214,870.17	218,758.18	219,332.84	219,919.00	220,516.87	221,126.71	221,748.74	222,383.21	223,030.37	223,690.48	224,363.78
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,787,044.07	195,044.52	191,220.12	187,470.70	183,794.81	180,190.99	176,657.83	173,193.95	169,797.99	166,468.62	163,204.53
Application Value 0,002 €/kWh	160,559.04	17,524.00	17,180.39	16,843.52	16,513.26	16,189.47	15,872.03	15,560.81	15,255.70	14,956.57	14,663.30
Additional Market Profits	857,238.70	78,288.63	79,854.41	81,451.50	83,080.53	84,742.14	86,436.98	88,165.72	89,929.03	91,727.61	93,562.17
Sum	2,804,841.81	290,857.15	288,254.92	285,765.72	283,388.59	281,122.59	278,966.84	276,920.48	274,982.72	273,152.80	271,429.99
Profit/Losses	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	72,098.97	68,922.08	65,846.73	62,871.72	59,995.88	57,218.10	54,537.27	51,952.35	49,462.32	47,066.21	44,766.21
Return on Investment		4%	3%	3%	3%	3%	3%	3%	3%	2%	2%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.026	0.026

Variant 3-3-24

General Conditions Biogas Plant		Utilisation [h/a]	Electricity Production [kWhel/a]
Rated Power [kWel]	1,000		
Installed Capacity [kWel]	3,000		
Padditional [kWel]	1,900		
CHP 1 [kWel]	1,000		
CHP 2 (additional CHP) [kWel]	2,000	2,854	5,708,000
Total Electricity Production [kWhel/a]	8,760,000		
Additional Earnings Electricity Market [€/kWel; rated a]	92.80		

Gas Storage	
Gas Storage [h] (6 h existing)	24
Additional Capacity [h]	18
Additional Volume [m³]	10776

General Conditions	
Electricity Purchasing Costs [€/kWel]	0.21
Interest	0.02
Term [a]	10
Inflation	0.02
Planning Costs [€]	40,000

Year of Operation		1	2	3	4	5	6	7	8	9	10
Capital Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional CHP	1,171,515.28	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73	130,420.73
Additional Gas Storage	140,401.76	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44	15,630.44
Fill Level Monitoring	10,000.00	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27	1,113.27
Gas Conditioning / Gas Pipe System	170,000.00	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51	18,925.51
Control System	4,000.00	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31	445.31
Transformer / Grid	160,000.00	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24	17,812.24
Investment Total without Interest	1,655,917.04										
Sum	1,843,474.94	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49	184,347.49
Supply Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Additional Parasitic Energy CHP		3,832.50	3,909.15	3,987.33	4,067.08	4,148.42	4,231.39	4,316.02	4,402.34	4,490.38	4,580.19
Parasitic Energy Gas Storage		321.66	328.09	334.65	341.34	348.17	355.14	362.24	369.48	376.87	384.41
Sum	45,486.86	4,154.16	4,237.24	4,321.98	4,408.42	4,496.59	4,586.52	4,678.26	4,771.82	4,867.26	4,964.60
Operational Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
CHP		4,143.50	4,226.37	4,310.90	4,397.12	4,485.06	4,574.76	4,666.26	4,759.58	4,854.77	4,951.87
Rated Power [kWel]		4,512.05	4,602.29	4,694.34	4,788.23	4,883.99	4,981.67	5,081.30	5,182.93	5,286.59	5,392.32
Gas Conditioning / Gas Pipe System		1,700.00	1,734.00	1,768.68	1,804.05	1,840.13	1,876.94	1,914.48	1,952.77	1,991.82	2,031.66
Control System		120.00	122.40	124.85	127.34	129.89	132.49	135.14	137.84	140.60	143.41
Transformer / Grid		1,600.00	1,632.00	1,664.64	1,697.93	1,731.89	1,766.53	1,801.86	1,837.90	1,874.66	1,912.15
Amount of Work		3,285.00	3,350.70	3,417.71	3,486.07	3,555.79	3,626.91	3,699.44	3,773.43	3,848.90	3,925.88
Sum	168,193.80	15,360.56	15,667.77	15,981.12	16,300.74	16,626.76	16,959.29	17,298.48	17,644.45	17,997.34	18,357.29
Other Costs	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Planning	40,000.00	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06	4,453.06
Official Permit	7,500.00	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95	834.95
Reports	3,500.00	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64	389.64
Insurance	100,927.68	9,217.37	9,401.72	9,589.76	9,781.55	9,977.18	10,176.73	10,380.26	10,587.87	10,799.62	11,015.62
Other Costs Total without Interest	151,927.68										
Sum	157,704.21	14,895.03	15,079.38	15,267.41	15,459.20	15,654.84	15,854.38	16,057.91	16,265.52	16,477.28	16,693.27
Costs	2,214,859.81	218,757.23	219,331.88	219,918.01	220,515.87	221,125.68	221,747.69	222,382.14	223,029.28	223,689.37	224,362.65
(Additional-) Revenues	€	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Flexible Premium	1,786,636.16	195,000.00	191,176.47	187,427.91	183,752.86	180,149.86	176,617.51	173,154.42	169,759.23	166,430.62	163,167.28
Application Value 0,002 €/kWh	160,522.39	17,520.00	17,176.47	16,839.68	16,509.49	16,185.77	15,868.40	15,557.26	15,252.21	14,953.15	14,659.95
Additional Market Profits	1,016,180.75	92,804.26	94,660.35	96,553.55	98,484.62	100,454.32	102,463.40	104,512.67	106,602.92	108,734.98	110,909.68
Sum	2,963,339.30	305,324.26	303,013.29	300,821.14	298,746.97	296,789.95	294,949.31	293,224.35	291,614.37	290,118.76	288,736.91
Profit/Losses	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a	€/a
Sum	86,567.03	83,681.41	80,903.13	78,231.10	75,664.26	73,201.62	70,842.20	68,585.09	66,429.39	64,374.26	62,320.13
Return on Investment		4%	4%	4%	4%	4%	4%	4%	3%	3%	3%
Additional Electricity Generation Costs through Flexibilisation [€/kWh]		0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.025	0.026	0.026

Appendix B: Reviewed Paper

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 Wilfried Zörner¹

Demonstration of Controllable Electricity Production via Biogas Plants

With the expansion of renewable, but fluctuating power generation from wind and solar energy, the demand placed on the security and reliability of supply is increasing. To ensure grid stability in the future, controllable power production via biogas plants has great technical and economic potential. In order to demonstrate the operation of controllable electricity production, an existing industrial-scale biogas plant was modified to produce electricity in accordance to the demands of the electricity market. In the course of scientific monitoring, extensive instrumentation was installed at the demonstration plant, which allows detailed evaluation of the operation of the limited gas storage volume and the behavior of the combined heat and power units (CHPs) during flexible operation.

Keywords: Biogas, Combined heat and power unit, Flexible electricity production, Gas storage, Smart grid

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1 Introduction

1.1 Motivation

In 2014, 95 GW of the total 203 GW installed [1] power generation capacities in Germany were based on renewable energies. By 2020, the ratio will be inverted. At this point, the power generation capacity of renewable energies will be more than twice that of conventional power plants. This evolution will continue in the years ahead [2].

This situation leads to several challenges. In times when the conventional power plants dominate, the fluctuating electricity production from wind energy and photovoltaic can be compensated easily. In the near future, the installed power generation capacities from renewable energies will exceed the ability of the conventional power plants to compensate for the fluctuating electricity production. This will lead to a lack or a surplus of electricity in the grid. Already, several wind turbines had to be temporarily shut down because the wind power generation exceeded the capacity of the grid.

Currently, the electricity production in most countries is only on demand. Due to the rising amount of fluctuating renewable electricity producers, the electricity production will be carried out primarily on its availability in the near future. This means that the production of electricity is not congruent with the demand and there will be periods with a lack or with a surplus of electricity in the grid.

During times of underproduction additional electricity generation is needed while during periods of overproduction the surplus electricity must be stored for periods of underproduction. To ensure grid stability in the future, potential solutions in the fields of load management and new storage technologies have to be developed.

Biogas has the ability to store electrical energy from renewable sources and can achieve a higher storage efficiency compared to pumped-storage hydroelectricity, compressed-air energy storage or hydrogen storage. Therefore, controllable power production from biogas has a high technical and economic potential.

1.2 Research Project "BioStrom – Controllable Electricity Production via Biogas Plants"

Controllable electricity production via biogas plants depends on various factors. Besides the stability of the biological process, cost is the main issue. To optimize the plant economics, efficient control strategies and system configurations must be chosen. These are currently not fully known and further research is necessary.

The aim of the project is the creation of a new area of application for biogas by enabling existing biogas plants to act as controllable electricity producers. Initially, a variety of approaches to transform existing biogas plants into controllable electricity producers were defined. In cooperation with the biogas plant manufacturer UTS Biogastechnik GmbH (Hallberg-

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moos, Germany) the most favorable modification concept was then selected and implemented on an existing biogas plant.

1.3 Literature Review

There exist several reports on controllable electricity production via biogas plants over short and long time periods. For the large-scale integration of renewable energies, combined heat and power units (CHPs) can significantly contribute to grid stabilization, as demonstrated in [3].

Szarka et al. [4] analyzed different technical concepts for a flexible power generation with biogas plants considering economic aspects. Both concepts require an extension of CHPs and heat storage which implies additional investments.

Hahn et al. [5] proved the ability of biogas plants to produce flexible electricity concerning the storage possibilities of biogas and the upgrading to biomethane as well as the flexible production of electricity by controlling the CHPs. Furthermore, they examined the feeding management by adding liquid substrates. Neither the flexibility of CHPs nor the improvement of the overall efficiency is considered.

The relation between storage requirements and feeding management has also been investigated [6] via a model-based research of demand-orientated electricity production, showing that a suitable feeding management enables significant reduction of the gas storage demand.

An alternative promising approach for demand-driven energy supply is given by daily adjusted biogas production rates in continuous processes via variable combination of the substrate feed [7]. Besides laboratory-scale experiments, which indicated a long-time stable process even under highly dynamic conditions [7, 8], determined via model-based calculations and full-scale experiments the potential of reducing the gas storage demand.

2 Demonstration Plant and Modifications

For the demonstration of controllable electricity production, the biogas plant Zellerfeld and its operators were made available. The biogas plant Zellerfeld was built between 2011 and 2012 and is jointly operated by three farmers. The commissioning of the plant took place in 2012.

The digester and post-digester of the plant are designed as partly subterranean, trafficable reinforced concrete tanks with a volume of 1800 m³. The digestate storage tank, also a partly subterranean reinforced concrete tank, is covered by an air-supported double-layer system used as gas storage. The digestate storage tank has a diameter of 32 m and a capacity of 6400 m³. The usable flexible volume of the gas storage is 2700 m³.

At the commissioning of the plant, a spark-ignition engine with an electric power of 549 kW_{el} was installed. The engine was operated with a rated output of 500 kW_{el}.

As part of the conversion to controllable electricity production in 2013, an additional cogeneration plant with an electric power of 889 kW_{el} was installed. Simultaneously to the commissioning of the additional CHP, the rated output of the bio-

gas plant was increased to 700 kW_{el}. During the monitoring period, the feeding rates and composition of the substrates were constant, and the overall costs for the modification amounted to 750 000 €. The plant data is summarized in Tab. 1.

Table 1. Data of biogas plant Zellerfeld.

Characteristic	Value
Rated power [kW _{el}]	~ 700
Installed power [kW _{el}]	1.438
CHP 1 [kW _{el}]	549
CHP 2 [kW _{el}]	889
Usable gas storage volume [m ³]	2700; air-supported double-layer system
<i>Used substrate</i>	
Cow manure	10 %
Rye silage (whole plant)	15 %
Maize silage (whole plant)	55 %
Sugar beet	20 %

2.1 Adjustments for the Controllable Electricity Production

For the controllable electricity production, the gas line, gas storage, and gas utilization were adapted according to the requirements of flexible operation.

Both CHPs are equipped with a preheating and -lubrication system. The preheating consists of an electric heater and a water pump integrated in the primary water circuit of the CHPs. During standstill of the engine, the temperature of the coolant is kept at about 60 °C. The prelubrication involves an oil pump, integrated in the oil circulation of the engine. The pump is switched on 1 min before the start of the engine to adjust the oil pressure. In order to cool down the turbochargers, the oil circulation continues for 15 min after the engine stop.

The fuel supply for both engines takes place via separate gas lines including gas drying in electrically powered gas coolers and fine desulfurization via activated carbon. To ensure the gas quality at the CHPs, the gas line gets purged with purified gas from the gas storage prior to the CHP start.

For the temporary storage of the gas, the existing air-supported double-layer gas storage over the digestate storage tank with an usable volume of 2700 m³ is employed. With the installation of additional CHP capacities, the maximum gas extraction rises from 250 Nm³_{Biogas}h⁻¹ to 750 Nm³_{Biogas}h⁻¹. So, the capacity of the air blowers, which are providing the supporting air for the gas storage, was adjusted to ensure the stability of the tank cover. The existing rope system for the measurement of the gas storage fill level was supplemented by a water gauge system.

2.2 Operation and Electricity Production Concept

The aim of controllable electricity production at the biogas plant Zellerfeld is to achieve a higher remuneration for the produced electricity by the use of the market bonus scheme, introduced in the EEG 2012 (renewable energies act) and the gained possibility of the direct marketing. For this purpose, the produced electricity is traded via an electricity marketer.

To achieve higher remunerations for the plant operators, the gas utilization capacities were increased as described. By taking advantage of the gas storage capacities, it is possible to adapt the electricity production of the plant to the control instrument, the electricity market.

The created flexibility of the plant can be described as below:

- The usable gas storage volume of 2700 m³ is sufficient to store the gas production of 6 h at a rated output of 700 kW_{el}.
- With the installed power capacity, the filled gas storage can be emptied within approx. 6 h by taking the further gas production within this period into account.

The analysis of the incentives for controllable electricity production indicates that with the Spot markets of the EPEX Spot SE, existing markets are available which are providing financial incentives for the controllable electricity production [9]. In order to create feasible schedules for the controllable electricity production, a linear optimization method was applied. Fig. 1 presents an electricity production schedule of the biogas plant Zellerfeld and the resulting gas storage fill level for a single day.

The input of the schedule is done manually by the plant operators in consultation with the electricity marketer via the system control. In this way, the schedule can be individually adapted to the current electricity prices, the current gas production or planned CHP maintenances. The processing with the electricity marketer takes place via the 15 min utility data of the energy supplier.

The biogas plant Zellerfeld shares the grid connection point with several photovoltaic (PV) plants with a maximum feed-in power of 5000 kW_{el}. With the total feed-in power of the biogas plant of 1438 kW_{el}, in total 6438 kW_{el} is attached to the grid connection point. The grid connection point is designed for a maximum feed in of 5000 kW_{el}. Thus, the capacity of the connection point is too low to ensure a simultaneous maximum feed-in of the biogas plant and the PV system.

Since an expansion of the capacity of the grid connection point during the project could not be realized, it was necessary to take the feed-in of the PV system into account within the scheduling of the electricity production of the biogas plant. For this reason, the flexibility of the electricity production is limited during periods of high solar loads. Thus, a sole electricity market optimized schedule was not possible.

Within the preparation of the implemented schedules the restriction by the grid connection

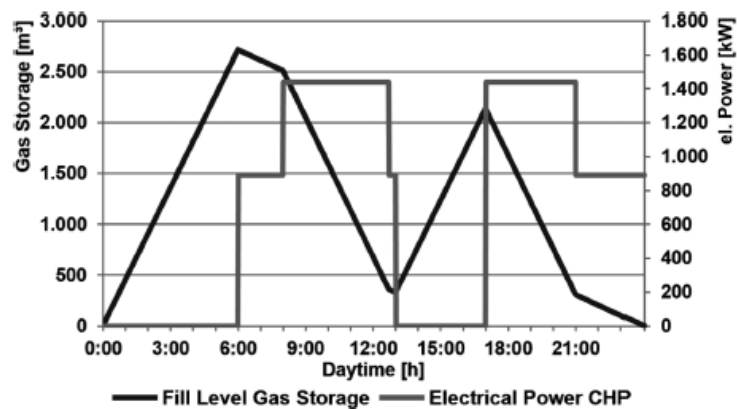


Figure 1. Electricity market optimized electricity production schedule of the biogas plant Zellerfeld.

point is taken into account according to the sunshine duration and intensity as described below:

- During times of high radiation, only CHP 1 with a nominal output of 549 kW_{el} is operated.
- In summer, the power of CHP 1 is additionally limited to 450 kW_{el} during noon.

Consideration of the PV system in the schedules is done manually and not beforehand. Thus, unexpected overloads of the grid connection point occurred at times. Beyond this limitation, the electricity production is optimized regarding the electricity prices.

3 Monitoring System

The aim of monitoring the demonstration plant is to ensure the effectiveness of the implemented measures and analyze the potential and limitations of the affected components, in order to optimize the controllable electricity production. For this purpose, measurement technology has been installed which allows detailed scientific monitoring of the controllable electricity production. The measurement concept is illustrated in Fig. 2.

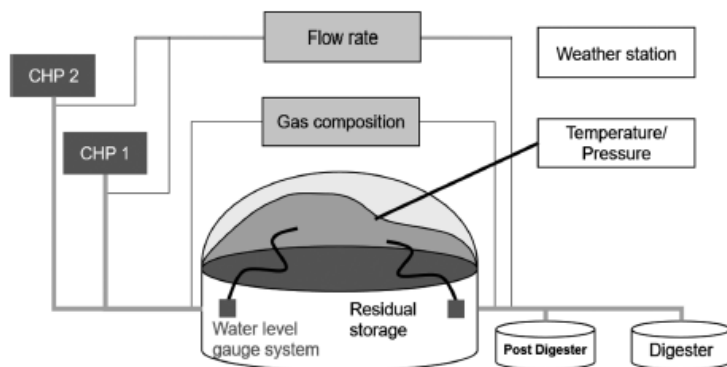


Figure 2. Measurement concept of the plant.

Monitoring of the gas storage is fundamental for analysis. For the determination of the gas storage fill level, a water level gauge system with three water level gauges is used. Additionally, the fill level is measured with a rope system. A comparison between these two systems is then possible.

The in- and outflowing gas of the biogas storage is also measured. For this purpose, the composition (CH_4 , CO_2 , and O_2) and the volume flow (thermal gas flow meters) of the biogas are assessed directly before and after the gas storage, as illustrated in Fig. 2. In order to determine the two CHPs individually, the volume flow is recorded before each CHP.

For the final accounting of the in- and outflowing amounts of energy, the water content of the biogas at the mass flow meters is compensated. The measurement of the temperature for the dew point determination of the incoming biogas takes place just before the gas storage. The water content of the CHP side of the gas storage is measured directly after the gas cooling unit of the gas drying system.

For standardization of the current gas storage volume, the temperature of the gas in the gas storage is measured in the middle of the freeboard, i.e., the space between the maximum fill level of the residue in the tank and the beginning of the usable gas storage space, approximately 1.5 m away from the inner wall of the tank. In addition, the absolute gas pressure in the gas storage is recorded.

To assess the environmental impact on gas storage conditions, a weather station was installed. Ambient temperature, relative humidity, atmospheric pressure, solar radiation, and wind speed are monitored at the altitude of the gas storage. In addition, the temperature of the substrate and the gas pressure in all of the tanks are measured in order to be able to analyze their effects on the controllable electricity production. To obtain electricity production data, the power output of each CHP was recorded.

4 Monitoring Results

4.1 CHP Operation

The histogram in Fig. 3 shows the relative frequency of the height of the electricity production from 07/01/2014 to 11/30/2014 (class width: 10 kW_d).

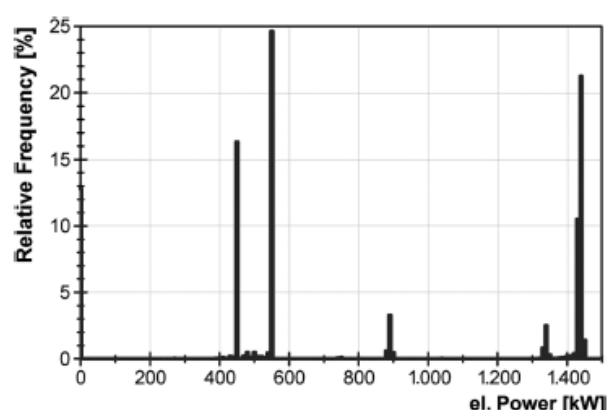


Figure 3. Histogram of the electric power generated at the plant (07/01/2014 to 11/30/2014).

The main areas of the power production are congruent with the implemented concept of the controllable electricity production. The histogram indicates how many times during the considered period which power has been produced in total. At 12.8 % of the time no electricity was produced, i.e., during the considered period the power generation has been suspended for 3 h a day on average. Overall, 43.1 % of the measured values are in the range of $450\text{--}550 \text{ kW}_d$ and 33.1 % between 1430 and 1450 kW_d . Visualization of the produced electric power demonstrates that the schedules entered from the operators can be reliably retraced.

Fig. 4 illustrates, representative for the normal operation of the controllable electricity production at the plant, the generated power and the gas storage level between August 13 and 16, 2014.

In comparison, Fig. 5 gives an example of the operation of the electricity production at a day with high solar radiation. The rated power during the time periods shown in Figs. 4 and 5 were each about 800 kW_d .

To compensate the low utilization of electricity production during conversion of the plant for controllable electricity production, the rated power of the plant was temporarily raised to 975 kW_d in order to produce the originally planned yearly amount of electricity. The corresponding operation schedule of the plant is illustrated in Fig. 6.

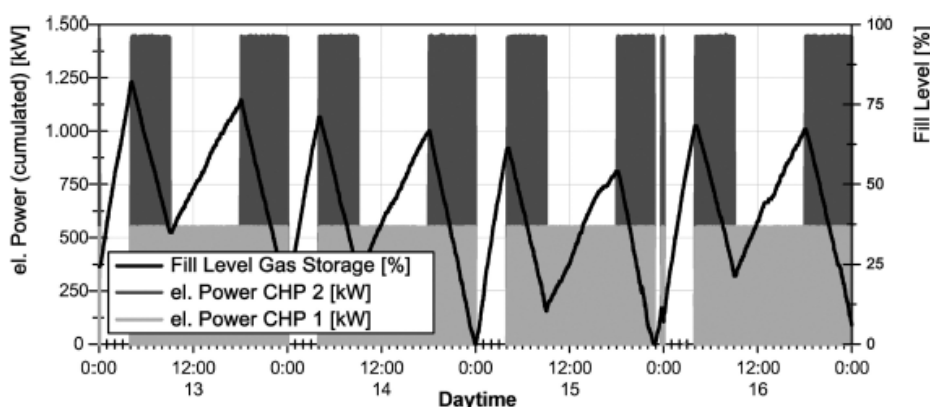


Figure 4. Normal operation of the plant (August 13–16, 2014).

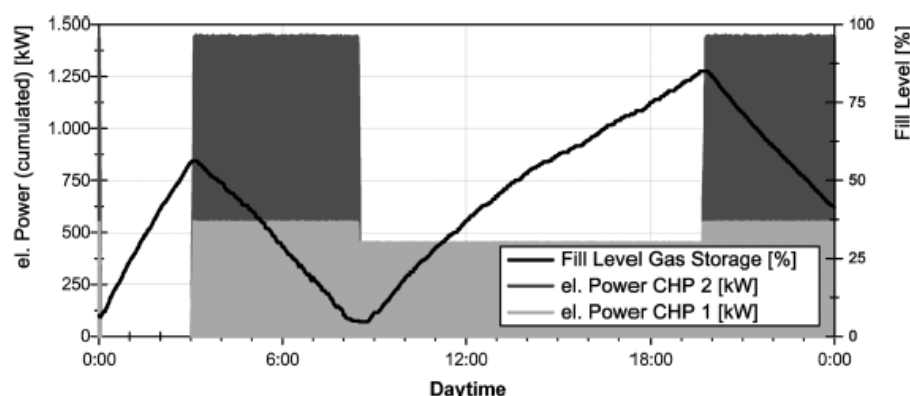


Figure 5. Operation mode of the plant at high solar radiation (06/20/2014).

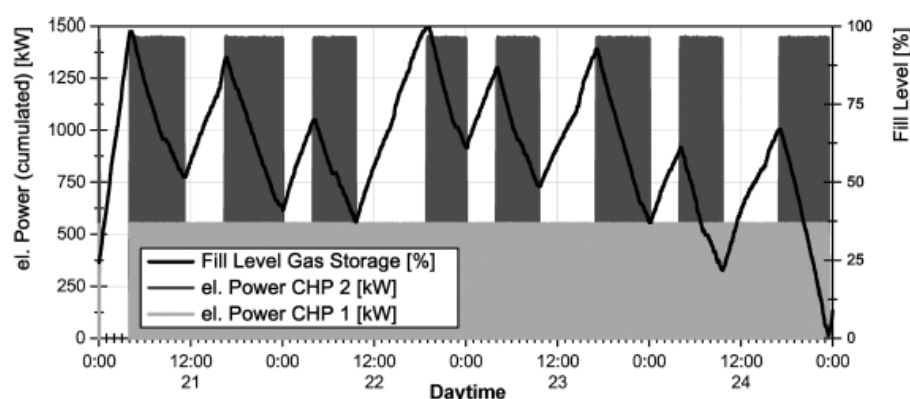


Figure 6. Operation mode at high rated power (November 21–24, 2014).

The starts of both CHPs were consistently reliable during the monitoring period. To assess the starting behavior, a typical start and shutdown process of the two CHPs is displayed in Fig. 7. The load increase of both CHPs begins after synchronization of the generators with the electricity grid. CHP 1 needs 145 s for synchronization, whereas CHP 2 starts after 90 s. The load increase of CHP 1 is carried out with about $2.5 \text{ kW}_{\text{el}} \text{ s}^{-1}$, that of CHP 2 with about $3.2 \text{ kW}_{\text{el}} \text{ s}^{-1}$. The nominal load of CHP 1 is achieved after 5 min and 15 s. CHP 2 reaches the nominal load after 6 min and 5 s.

The switch-off of both CHPs is completed after 2 min and 55 s. The load reduction at CHP 1 is carried out with $3.1 \text{ kW}_{\text{el}} \text{ s}^{-1}$, at CHP 2 with $5.1 \text{ kW}_{\text{el}} \text{ s}^{-1}$.

The measured volume rates and gas composition enables an assessment of the electrical efficiencies of the CHPs. The efficient value calculated from the measured values at nominal load at CHP 1 is between 39.5 % and 40 %, that of CHP 2 between 43 % and 44 %. So, the electrical efficiency of CHP 1 is lower than its value in the technical data sheet with 40.7 %. In the technical data sheet of CHP 2 an electrical efficiency of 42 % is given. Thus, the measured values of CHP 2 are between 1 and 2 percentage points higher than the specifications of the manufacturer.

As described, CHP 1 is temporarily operated in partial load with an electrical power output of $450 \text{ kW}_{\text{el}}$ (82 % of the nominal load). During the operation in partial load, the measured electrical efficiency decreases to 38–38.5 %. The alternating use of both CHPs led to no negative effects. So the installed CHPs are suitable for a controllable electricity production.

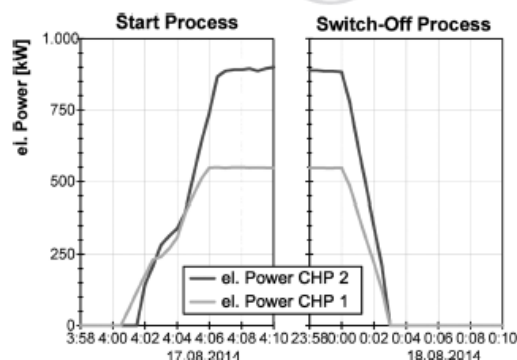


Figure 7. Power provision during start and shutdown process of the CHPs.

4.2 Gas Storage Operation

The objective of the gas storage operation for controllable electricity production is to exploit the available gas storage volume completely and as uniformly as possible. Due to the limitations through the grid connection point of the demonstration plant

the flexibility of the electricity production is limited. So the schedules of electricity production could not be fully optimized for the available storage volume. The histogram in Fig. 8 illustrates the utilization of the available gas storage at the plant between 07/01/2014 and 11/30/2014.

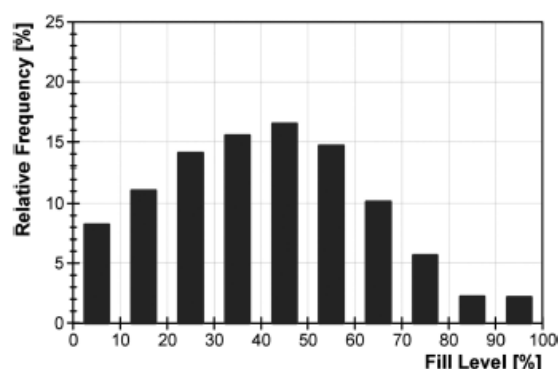


Figure 8. Utilization of the gas storage (07/01/2014 to 11/30/2014).

The gas storage was not used uniformly. The fill level of the storage is far more frequently in the range of 0–40 % than between 60–100 %. Fill levels between 80–100 % are exploited only sporadically. Typical time courses of the gas storage fill level are illustrated in Figs. 4, 5, and 6.

The gas storage volume is not fully utilized and this leads to a relatively frequent (20 % of the days in the considered period) shutdown of the CHPs due to an underrun of the minimum gas storage volume. The shutdown is necessary to avoid negative pressure in the gas storage. Such a security shutdown is illustrated in Fig. 4 on August 15 shortly before 11 pm.

Suboptimal gas storage utilization can be attributed to an inadequate adaption of the feeding quantity and thereby the produced amount of biogas at the defined rated power of the electricity production on which the schedules are based.

4.3 Gas Storage Conditions

Fig. 9 indicates the temperature of the gas in the gas storage at the coldest and warmest day of the year. In order to analyze the influence of environmental conditions on the temperature of the gas in the storage, the ambient temperature, the temperature of the substrate in the residual storage tank, the temperature of the incoming gas from the digesters, and the solar radiation are visualized. The temperature of the stored gas follows the ambient temperature, in both summer and winter.

A direct influence of the solar radiation on the temperature in the storage cannot be recognized. However, under warm weather conditions during times of high solar radiation the temperature of the incoming gas, which is flowing through above ground laid gas pipes made of stainless steel, rises partially by 5 °C because of the radiation. At cold ambient conditions the incoming gas tends to the ambient temperature. The temperature in the gas pipes between the digesters and the gas storage cools down by 15 °C in com-

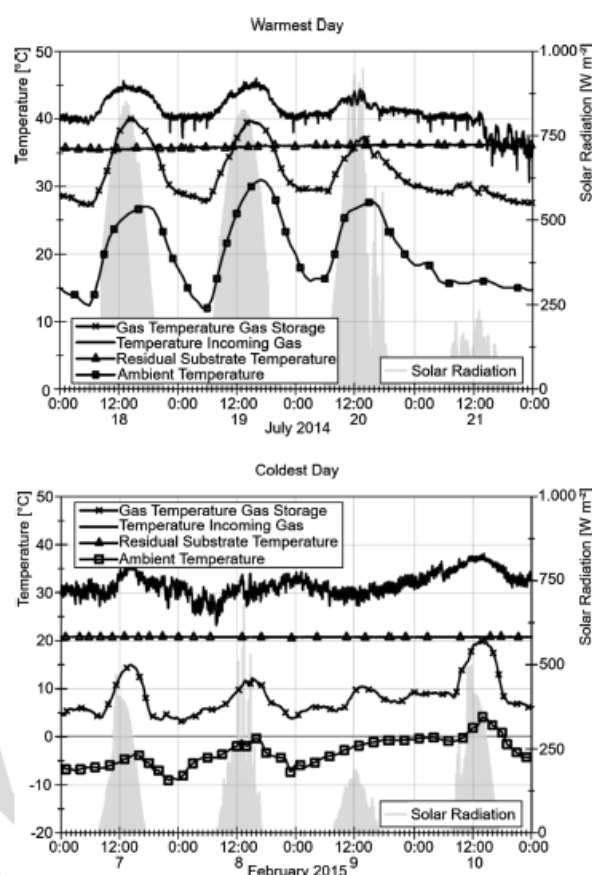


Figure 9. Temperature in the gas storage and influential factors from July 18–21, 2014 (warmest day) and February 7–10, 2015 (coldest day).

parison to the gas temperature in the digesters of about 25 °C.

The highest gas temperature in the storage was measured on July 18, 2014 (cf. Fig. 9a) with 40 °C. The theoretical maximal storable standard volume at this time was 2133 Nm³. This corresponds to 79 % of the absolute value of the usable volume. The lowest temperature of the gas in the gas storage was 3 °C on February 8, 2015 (cf. Fig. 9b). Based on these conditions a theoretical maximal storable standard volume of 2570 Nm³ results, i.e., about 95 % of the absolute value of the usable volume, results. Thus, at very cold outdoor conditions, up to 20 % more energy can be stored in the gas storage, in comparison to very warm ambient conditions. During the day, the storable standard volume varies both in summer and winter by up to 170 Nm³.

4.4 Gas Storage Management

For demand-oriented biogas utilization, priority must be given to gas storage management, the aim of which is to reproduce and control the current storage situation with sufficient accuracy. It must be ensured that the produced gas can be stored

and utilized at any time. At the same time, the scheduled demand must be covered. So, the produced amount of gas, the stored amount of gas, as well as the gas demand must be known at all times.

For the used air-supported double-layer system, the fill level of the storage is determined by measuring the position of the inner gas storage membrane. Since the pressure in the gas storage space and in the space between inner and outer membrane is almost identical, the gas storage membrane can be formed irregular, depending on the flows in the gas storage space and the supporting air space. This is a challenge for different measuring methods regarding the determination of the position of the inner membrane.

The rope of the rope system is led in a straight line over the center of the storage, whereas the three water level gauges are fixed around the center gas storage. The measured values of each water level gauge are averaged.

Fig. 10 shows a comparison of the two systems. In the illustration, an adjustment of the measured values of the rope system is indicated. It is clearly evident that shortly after the adjustment, the lower fill level as well as the upper fill level of the rope system is up to 20 percentage points lower than the values of the water level gauges system. This demonstrates the difficulty to interpret the values of the rope system. This can be attributed to possible existing bulges of the inner membrane, which are not detected by the rope. A controlled operation of the electricity production just by means of the installed rope system is not possible due to these uncertainties.

The measured values of the water level gauge system were plausible during the monitoring period. The operating pressures of the gas storage were in a permissible area for the operation of the gas storage at any time. This indicates that the fill level limits at 5 % and 95 % are adequate.

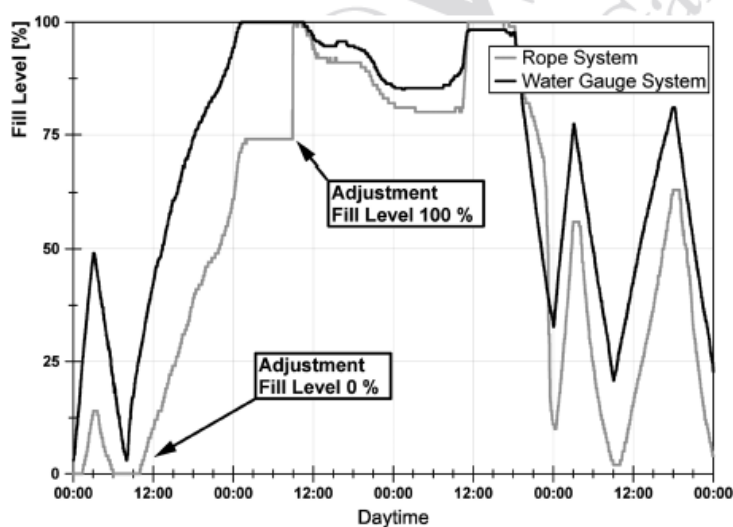


Figure 10. Comparison of rope system and water gauge system during the adjustment of the rope system.

5 Conclusions

The demonstration of controllable electricity production at the biogas plant Zellerfeld has proven that a schedule-based flexible operation of electricity production is possible. For an optimized scheduling and an optimized utilization of the available gas storage it is important to reach the planned amount of gas production, especially when the gas storage volume is limited.

It can be stated that the exact knowledge of the measurement characteristics for the fill level monitoring and the conditions in the gas storage under different ambient conditions allows a better utilization of the available gas storage volume for the purposes of controllable electricity production. Thus, safety buffers can be reduced and the flexibility of the electricity production can be exploited.

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The authors have declared no conflict of interest.

Abbreviations

CHP	combined heat and power
EEG	German Renewable Energies Act
PV	photovoltaic

References

- [1] Bundesministerium für Wirtschaft und Energie, *Zahlen und Fakten Energiedaten*, Bundesministerium für Wirtschaft und Energie, Berlin 2016.
- [2] Sachverständigenrat für Umweltfragen, *100% erneuerbare Stromversorgung bis 2050: klimaverträglich, sicher, bezahlbar*, Sachverständigenrat für Umweltfragen, 2010.
- [3] H. Lund, A. N. Andersen, P. A. Østergaard, B. V. Mathiesen, D. Connolly, *Energy* **2012**, 42, 96–102. DOI: 10.1016/j.energy.2012.04.003
- [4] N. Szarka, F. Scholwin, M. Trommler, H. F. Jacobi, M. Eichhom, A. Ortwein et al., *Energy* **2013**, 61, 18–26. DOI: 10.1016/j.energy.2012.12.053
- [5] H. Hahn, B. Krautkremer, K. Hartmann, M. Wachendorf, *Renewable Sustainable Energy Rev.* **2014**, 29, 383–393. DOI: 10.1016/j.rser.2013.08.085

- [6] J. Grim, D. Nilsson, P.-A. Hansson, Å. Nordberg, *Energy Fuels* **2015**, 29 (7), 4066–4075. DOI: 10.1021/ef502778u
- [7] E. Mauky, H. F. Jacobi, J. Liebetrau, M. Nelles, *Bioresource Technol.* **2015**, 178, 262–269. DOI: 10.1016/j.biortech.2014.08.123
- [8] E. Mauky, S. Weinrich, H.-J. Nägele, H. F. Jacobi, J. Liebetrau, M. Nelles, *Chem. Eng. Technol.* **2016**, 39 (4), 652–664. DOI: 10.1002/ceat.201500412
- [9] G. Häring et al., *DBFZ Jahrestagung 2014, BioStrom – Steuerbare Stromerzeugung mit Biogasanlagen*, Leipzig, October **2014**.

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